2. To improve the technologies for estimating fertility and mortality when only incomplete or inadequate data exist (including techniques of data collection);

3. To evaluate the factors determining the changes in birth rates in less-developed nations.

Given the magnitude of these tasks, the Committee decided to concentrate its initial efforts on the first two tasks; it initiated work on the third task in 1979.

The Committee approaches the first task through careful assessment, by internal and external comparison, and through analysis, by application of methods judged to be the most reliable, of all the data sources available. Each of the country studies therefore consists of the application of a range of methods to a number of data sets. Estimates of levels and recent trends are then developed on the grounds of their consistency and plausibility and the robustness of the individual methods from which they were derived.

The Committee's second task, refinement of methodology, is seen as a by-product of achieving the first. The application of particular methods to many different data sets from different countries and referring to different time periods will inevitably provide valuable information about the practical functioning of the methods themselves. Particular data sets might also require the development of new methodology or the refinement of existing techniques.

In carrying out its first task, the Committee set three criteria for identifying countries to study in detail: that the country have a population large enough to be important in a world view; that there be some uncertainty about levels and recent trends of fertility or mortality; and that sufficient demographic data be available to warrant a detailed study. After a country has been selected for detailed study, the usual procedure is to set up a panel or working group of experts, both nationals of the country and others knowledgeable about the demography and demographic statistics of the country. The role of these panels and working groups, which generally include at least one Committee member, is to carry out the comparisons and analyses required. A small staff assists the Committee, panels, and working groups in their work.

As of early 1981, 162 population specialists, including 89 from developing countries, have been involved in the work of the Committee as members of panels or working groups. The Committee, the Assembly, and the National Research Council are grateful for the unpaid time and effort these experts have been willing to give.

As part of the second major task, and given the importance of data collection in estimating fertility and mortality, the Committee established the Panel on Data Collection, chaired by William Seltzer, a member of the Committee. The specific objective of the Panel on Data Collection is to assist the Committee on Population and Demography in developing recommendations for improving and standardizing techniques for estimating fertility and mortality levels, trends, and patterns in developing nations. To this end, the panel has focused on methods of improving the accuracy, coverage, timeliness, and reliability of such estimates through improvements in the collection of underlying data.

This report is No. 4 in a series produced by the Committee. It is the first report from the Panel on Data Collection. The report reviews the data and conclusions of studies of age misreporting errors, age-selective underenumeration, and the interview process regarding the collection of information on age. The report also reviews techniques used to detect distortions in reported age distributions, and it describes typical patterns of distortion and how these distortions affect demographic estimation procedures.

Age misreporting is only one type of response error that arises in data collection processes. Others include underreporting and misdating of vital events, inaccurate reporting of information on individual and household characteristics, and the failure to include required or requested information. Age misreporting is troublesome, and surprising to some non-demographers. However, other survey and census variables--for example, income--often have even larger errors. More is known about age misreporting than about the errors in most other variables used in survey research--in part because the problem has been studied, albeit not as extensively as many users of demographic data would want, and in part because age has several favorable features that most other variables lack: (1) it increases linearly with time, and hence strong modeling possibilities exist; (2) much is known about age, through certificates and rituals, for example; (3) it correlates to some extent with visible body features; (4) age is not as socially sensitive a variable as some others (for example, abortion, crime, contraception, wealth, income, attitudes) and is thus less sensitive to limitations of data collection processes; (5) a person's age is often better known to other household members than are other variables, and hence it can be reported more easily by proxies; and (6) age is an objective measure, in contrast to attitudes, for example. Thus, although the substantial extent and effects of age misreporting are by no means completely understood, our knowledge about age misreporting as response error is comparatively quite good, and studies of age misreporting may serve as prototypes for the study of other types of response errors.

This report was prepared by Douglas C. Ewbank, Department of Population Sciences, Harvard School of Public Health. The Panel on Data Collection asked Dr. Ewbank to undertake this study, and Panel members have offered comments on earlier drafts. William Seltzer provided the spark that led to the initial design of the study and recommended a number of important references. The staff of the Committee provided help in locating copies of a number of the less accessible references, and the Committee's editor, Katherine Miller, provided a great deal of valuable editorial advice. The report has also benefited from comments and insights provided by members of the Committee and the Assembly of Behavioral and Social Sciences during their reviews of the manuscript. The assistance of the Committee staff in typing the drafts and final copy of the text and tables is much appreciated. Particular thanks are offered to Solveig Padilla and Benita Anderson.

Finally, the Committee and the Panel express sincere appreciation to Douglas Ewbank. As is often the case with reports of this nature, the task grows as it proceeds, and Doug has given generously of his time in drafting, rewriting, and revising this report.

ANSLEY J. COALE, Chairman
Committee on Population and Demography

1 Introduction

Any demographer working with data from developing countries has heard stories about the grey-haired old lady in India (or Nigeria, or Peru) who reports that she is absolutely sure she is either 25 or 69 years old. Although age misreporting, in this form and many others, has plagued demographers for centuries, studies that document the extent and nature of such reporting problems are few and far between. In the late 1960s, two books were published that laid the methodological foundations for studying fertility and mortality in populations for which reliable vital statistics are not available. These milestone books--Manual IV: Methods of Estimating Basic Demographic Measures from Incomplete Data (United Nations, 1967) and The Demography of Tropical Africa (Brass et al., 1968)--both included extensive discussion of the patterns of age misreporting that are common in developing countries.

Since then, the basic methods of estimating fertility and mortality rates from census and single-round survey data have been improved and new similar methods have been introduced. However, little progress has been made toward updating our understanding of patterns of age misreporting and age-selective underenumeration. There have been two studies of the interview process, which provide some insight into the source of the errors (Quandt, 1973; Gibril, 1979); several attempts to measure age misreporting errors (Caldwell, 1966; Scott and

Sabagh, 1970; Caldwell and Igun, 1971; Gil et al., 1971; Gibril, 1975; MacDonald et al., 1978; Pison, 1979, 1980); and a few attempts to measure the age-sex pattern of underenumeration (for developing countries: Park, 1966; for the United States: Marks, 1978; Marks and Rumford, 1978). This report reviews extensively the data and conclusions of these studies. However, these efforts to increase our knowledge of the causes of distortions in reported age distributions have been small in comparison to the opportunities.

For example, two recent studies of age misreporting (Ueda, 1976; Kamps, 1976) use only such gross indexes of misreporting as the Whipples index and the U.N. indexes, which measure the smoothness of the age distribution. They make no attempt to explain the patterns in terms of stable population analysis, census survival, or distortions in other distributions (such as the distribution of women by parity or marital status). Similarly, several recent post-enumeration studies of age misreporting and underenumeration have provided some interesting new data, however they have rarely been tabulated in ways that help us understand why misreporting occurs or how it affects estimation procedures.

It appears that demographers have decided that distorted age distributions are something we will have to learn to live with. The major efforts at remedying the situation have been aimed at improving the design of questionnaires, primarily through the use of historical events calendars, which are used to help respondents date events. (The appendix evaluates in detail experience in using such calendars.) Unfortunately, the use of these calendars is relatively expensive and the evidence of their effectiveness suggests that the results they achieve are not worth the price, except possibly for children.

Chapter 2 of this report reviews what is known about the sources of age misreporting, including respondents' ignorance, interviewer bias, and even simple data processing errors. Chapter 3 reviews the techniques that can be used to study distortions in reported age distributions that are due to age misreporting and to age-selective underenumeration. It includes discussion of post-enumeration surveys, which have been conducted at great expense in several developing countries, as well as stable population analysis and census survival techniques, which are virtually free and underutilized.

It also compares the results from some of these studies by applying both stable population analysis and census survival techniques to data that have been adjusted for underenumeration and age misreporting.

Chapter 4 discusses our current knowledge about the patterns and amount of age misreporting and underenumeration and emphasizes the importance of paying more attention to age- and sex-selective underenumeration. Although it appears that age misreporting is probably the larger problem, selective underenumeration is also significant and may be somewhat easier to eliminate and to measure.

Chapter 5 examines what is known about how distortions in reported age distributions affect estimation procedures and suggests a few approaches for future research. This analysis suggests that age misreporting may set limitations on some of the Brass procedures for estimating fertility and mortality, which are so widely used in demographic analysis.

To date, the constraints of cross-cultural comparison and the small number of studies that directly address the problems make it difficult to generalize confidently about the causes and effects of age misreporting and age-selective underenumeration. However, the available evidence does suggest some promising avenues for further investigation. The final chapter recommends directions for future research and suggests analytical approaches that may prove especially fruitful. The recommendations include making new tabulations of existing data, reviewing the distortions in the 1970 round of censuses, and duplicating a few of the more useful studies in different social settings. There is reason to believe that a slight redirection of current research on the causes of the distortions in reported age distributions can produce practical new approaches to dealing with inaccurate data.

2 Sources of Age Misreporting

An understanding of the sources of age misreporting is a prerequisite to improving age reporting and to adjusting for the effects of misreporting during data analysis. Errors in age reports can occur at many stages of the data collection process, and the remedies and adjustments required depend on the source and the nature of the error.

The whole process of data collection is aimed at collecting certain pieces of information and transmitting them to punch cards or computer tape which can be used for descriptive tabulations and analysis. When the data collection depends on interviews, it is assumed that the person being interviewed has the information the researcher needs. The interview process is designed to extract the needed information and record it. This first record is often coded, reviewed for internal consistency, keypunched, and checked again for consistency before it reaches the form in which it will be used by the analyst (cards, computer tape, or published tables).

Using this concept of the data collection process, we have divided the discussion of sources of age misreporting into four parts. The first section reviews the types of direct knowledge about age that an interviewee might have to offer. The second section describes other information the interviewee might have that can be used to estimate age if it is not known exactly. The third section reviews the interview process and the problems of extracting the information and using it to supply answers to the questions on the interview form. The fourthsection reviews briefly the kinds of error that can arise in the course of transferring the information from interview forms to computer cards or tape.

THE KNOWLEDGE OF AGE

Interviewees generally have some knowledge about their age, although it may be non-numeric. The knowledge ranges all the way from exact age or exact date of birth to the vaguest of generalizations (for example, "old enough to have grandchildren"). Most problems of age misreporting begin with the interviewee's ignorance of exact numbers. This takes two forms: ignorance of one's own age and ignorance about the ages of others about whom questions are asked.

The Problem of Proxy Reporting

In a household interview, there is frequently one respondent who supplies the majority of the information. In societies in which one's own age is not important, the ages of others may seem even less important. In their discussion of age reporting in a Nigerian survey, Caldwell and Igun (1971:292-293) report that even though the interviewers were instructed to see all persons in each household, the only age-sex groups in which at least 50 percent of the persons reported their own age were males aged 15-44 and females aged 15-19. In all other groups the reported age was based in the majority of cases on the reports of a third party or on interviewer estimates. Although it is not reasonable to expect infants to report their own age, it is disturbing to learn that the age reports about middle-aged women are often based on the opinion of "a more literate neighbor or a nephew who tries to be helpful." Quandt's study of transcripts of interviews from the 1971 Moroccan census reports that of those aged 15 and over, 45 percent had their ages reported by other individuals without the help of registration cards or documents (Quandt, 1973:64).

This failure to derive the information on age from the person most apt to have useful knowledge is clearly one source of error. Agarwala has studied age reporting in the Mysore survey in India (1960) in which several methods of estimating ages were tested. He compared the amount of digit preference among ever-married persons for two estimates of age: (1) age reported by the head of household and (2) age reported by the individual himself. The reports of the household heads led to a value of 0.91 on the Myers index of digit preference, whereas reports by the individuals had an index of only 0.75. The difference was larger for males (0.98 as compared to 0.72) than for females (0.86 and 0.79), which is surprising because for males who are household heads the two reports should be equal. The data, based on reports from 46 married couples, show that there might be a slight tendency for the household head to report a higher age for an individual than would the individual.

Uncertainty in First-Person Reports

Although interviewing third parties often yields unreliable estimates of an individual's age, asking the individual directly does not necessarily improve the estimate. In societies in which birth registration is uncommon and in which exact ages are not important, there is often a fundamental lack of knowledge about age. This was clearly expressed by one Moroccan woman in this exchange with a census enumerator (Quandt, 1973:45):

> "What is your age?"
>
> "Who me? Our generation was unrecorded. We didn't have any. No date of birth. Nothing."
>
> "How many (years), how many? Estimate?"
>
> "How am I going to estimate? I have nothing to estimate with. I can tell you that I am 60 years; 70 I haven't yet reached."
>
> "Have you reached 80?"
>
> "I don't think so. Someone who is 80 is . . ."
>
> "You who still have energy, you are 70."
>
> "Perhaps that, perhaps it is correct, sir."

Quandt found many such expressions that indicated the respondent's awareness of his or her own ignorance of exact ages. Phrases such as "I don't know," "perhaps," and "he might be..." were found in the responses of 69 percent of the households in her sample (1973:45). Gibril reports exactly the same types of expressions in his study of recordings of census interviews from Gambia (Gibril, 1979:30). It appears, therefore, that a large part of age misreporting is due to respondents' ignorance of exact ages and dates and that this problem is compounded by third-party reports of age.

The information respondents do have about age takes many different forms. In some cases it is based on birth registration cards or other official documents that provide at least an estimated age for the person at some specific date in the past. This might include school registration documents, work permits, or village register books.

Such sources of information were very important in Morocco. Quandt's reports show that people often responded to the age questions by searching for official documents (Quandt, 1973:45):

> "How old is (your wife)?"
> "Wait, I will look for her identity card."
> "You don't have a paper for her?"
> "Who do I work for, that I would be able to have papers? Look, sir, in these papers if there is something . . ."

As in this case, many respondents seem to take refuge in the official forms, frequently refusing even to report the age and giving the enumerator the document to read for himself. Although these forms may be of questionable validity, they at least provide some basis for an estimate. Since errors in age estimation increase with age (as is demonstrated in Chapter 5), guesses about age made at an earlier date may be more reliable than new estimates.

Documents that provide age estimates can be very misleading, especially when the documents can be valuable to the bearer for such things as obtaining Social Security benefits or deferring a military draft. For example, one doctor in a developing country was convinced he could document a case of a woman who had delivered a baby when she was 65 years old. Although this is possible, it is far more likely that the woman's birth certificate is incorrect. For this reason it may be useful for interviewers to make a note of where and when the documents were issued. Documents may be incorrect due to deliberate falsification of information by the respondent or simply due to uncertainty or lack of knowledge at the time the document was prepared. This is more likely to be a problem when the document represents delayed registration of the event or when proxy reporting is involved. For example, a man obtaining a household registration booklet may be asked the age of his wife. If he replies "don't know," the clerk may guess: the man is 40, so his wife may be 30. If the registration occurred in 1977, the year of the wife's birth is recorded as 1947 in the booklet. Future data collectors may be shown the booklet when asking for age information.

In some cases the respondent appears to know his or her date of birth exactly, but only in terms of a calendar different from the one the interviewer uses. For example, in some Chinese societies, many individuals can give their exact date of birth according to the traditional Chinese calendar but cannot report their age at last birthday according to the Western calendar (Seng, 1959; Saw, 1967; Cho, 1971). Quandt reports that in Morocco some respondents could give their date of birth in Islamic months and years.

A recent study of fertility and mortality in South Korea by Coale et al. (1980:37-40) demonstrates that the failure to convert from the Chinese calendar to the Western calendar during the 1970 census led to distortions in the single-year age distribution. The reason for the distortions is that some Chinese years include 12 lunar months while special "leap" years have 13 months. The situation becomes even more complicated when different events are reported by the same person using different calendars (Scott and Singh, 1980:37).

A similar situation exists when respondents can report the exact date or number of years since an age-related event in their lives. For example, Scott and Sabagh report that in Morocco men often can report the number of times they have observed Ramadan (1970:102). Since this practice is celebrated annually beginning at puberty, this information can be combined with an estimated age at puberty to estimate current age.

Blacker (1965) investigated a similar situation in Kenya where some tribes have elaborate circumcision ceremonies. Although individuals rarely can give the exact year in which they were circumcised, they usually can report the name given to their circumcision group. Since only one group is circumcised each year, it is possible to construct a conversion table relating the names of the circumcision groups to Western calendar years. Using an estimated age at circumcision, these group names can serve as age grades, which make it possible to estimate age for individuals. Although Blacker found the method relatively reliable, he points out that not all tribes have these customs and that local conversion tables would be needed for each small area. A similar institution--the Gambian kafo, or childhood playgroup--was used to estimate age in the Medical Research Council's study of several villages in Gambia (Gibril, 1975:7), and Pison has used circumcision dates in Senegal (1980).

In addition to providing information about such age-related events as puberty rights, individuals generally can provide some information about their approximate age at the time of a specific event. For example, when asked her age in relation to a particular event, one Gambian woman reported, "By then, I was a small girl" (Gibril, 1979:38). It is this kind of information that justifies using local calendars of historical events to help estimate ages. In a less formal way, some respondents use their own personal calendar of events to estimate the ages they report. For example, in the Moroccan census one man reported that a farm laborer living with him was 53 years old because he knew that the man was 30 years old when he came to work on the farm and that he had been there 23 years (Quandt, 1973:47).

Some respondents can provide information only about relative ages within small communities. In a few societies, where there are strict rules regarding the forms of address to be used when speaking to anyone who is older, it is reasonable to expect that such reports of relative ages are generally accurate. In a study of a group of !Kung bushmen of the Kalahari, Howell assigned each member of the study population an age that was consistent with both the information on relative ages and with an age distribution estimated from stable population analysis (Howell, 1979:24-42).

Clearly, in many societies there are people who do not know their own age or date of birth, however most have some information that would be useful in estimating their age at some point in the past. One approach to collecting more accurate age data is to design survey questions that elicit some of this incomplete knowledge of age.

INDIRECT PROCEDURES FOR ESTIMATING AGES

In addition to exact knowledge of age and information about relative ages or a person's age at some time in the past, there is information that can be used to estimate age indirectly. The most important information of this sort relates to the life stage of an individual, for example: can a child walk yet, has a girl had her first menstrual period, has a young woman or man been married yet, do they have children, do they have grandchildren, etc. All of these questions attempt to locate the individual within a natural sequence of life events that generally occur during a relatively fixed period of a few years of age. For example, in most developing countries the mean age at menarche is 14 or 15 years. Therefore, any girl who has had her first period is probably at least 14.

Information of this type apparently is used by interviewers whether or not they are instructed to do so. For example, Quandt quotes an extensive discussion between an interviewer and a local official about whether a woman with a 13-year-old child could be as young as 27 (1973:56-57). The discussion revolves around their perceptions of the age at which women get married and the earliest age at which women bear children. Clearly, interviewers use such characteristics and visible signs of age to determine when a reported age is apt to be unreliable.

Although using data on marital status and parity might be the simplest way to get a reasonable estimate of ages, especially ages of young adults, it is not necessarily advisable. As we will see later, this approach causes grave difficulties when the data are also used to study marriage and fertility. If parity and marital status are used to estimate age, then looking at marital status or parity as a function of age involves circular logic and provides no real information about marriage or childbearing.

In addition to creating problems for analysis, using parity and marital status leads to distortions in the reported age distributions. Caldwell and Igun's studies (1971:299) in Nigeria led them to conclude the following:

> There is a significant tendency amongst 15- to 19-year-old females for marital and parity conditions to affect age enumeration. The single have a somewhat greater chance of having their age understated than overstated, while the married are much more likely to have their ages overstated.

Although this problem rarely has been documented carefully, other authors have repeatedly stressed that this type of bias exists in age data from a number of societies, especially those in Africa and southern Asia (U.N., 1967:21; Krotki and Beaujot, 1975:355).

Agarwala (1960) tested approaches to age estimation that depend on reports of such things as duration of marriage and intervals between births. For example, one simple method of this sort is to estimate the current age of an ever-married woman as the sum of her reported age at marriage and her reported duration of marriage. This estimate might be more reliable than a simple statement of age if the age at marriage in a population has a small variance and if the duration of marriage can be reported relatively well. There is reason to believe that a good estimate of duration is possible, because the duration of marriage is frequently close to the age of the firstborn child, which is easier to estimate than the age of the mother. Agarwala used several similar approaches for estimating the age of other members of the population and determined that such methods do produce reported age distributions with a lower U.N. index of age misreporting than that of simple reports of age. However, he was not able to compare the accuracy of these reports with more reliable estimates, such as those based on comparisons with birth certificates.

THE INTERVIEW PROCESS

In the two previous sections we discussed the kinds of information that are available to interviewers for determining a person's age. The age that is actually recorded on the questionnaire depends on the type of information the interviewer is trained to use, the methods he or she is trained to apply, and the actual procedures followed. It is important to look separately at the techniques that are recommended in training sessions and the techniques that interviewers actually employ.

Questionnaire Design

The first question that faces the designer of a survey questionnaire is whether to ask for reports of age or date of birth or both. This decision rests on a determination of which of the two facts the individuals are more apt to know or which they are apt to report more accurately. Studies done in Chinese societies have shown that it is possible to improve age reporting by asking for date of birth according to the traditional Chinese calendar (Seng, 1959; Saw, 1967; Cho, 1971) and that it is imperative that the reporting system is clearly specified. Gray and Gee studied age reporting errors in several censuses in England and Wales and concluded that asking for date of birth produces better results, with the possible exception of children (Gray and Gee, 1972:110). In the United States, evidence shows that asking for reports of both age and date of birth and then reconciling them for consistency has led to different and less severe patterns of digit preference in the reported age distribution. The 1980 census of the United States included questions on both age and date of birth.

In their review of age reporting in Thailand, Chamratrithirong et al. (1978) discuss the Thai tradition of using the "going-to" age (yang). Their study revealed that in the 1960 census many people responded to the question on "age last birthday" with their age next birthday. This reporting error complicates comparisons between the 1960 census and the 1970 census, which asked for date of birth. In this situation it is clearly advisable to ask for date of birth, since it leads to less confusion.

When techniques for estimating ages are recommended (e.g., events calendar, use of parity, etc.), it is important that the question asked matches the recommended technique. Some estimation techniques produce estimates of age and some produce estimates of date of birth. The recommended techniques must be compatible with the question asked so that interviewers do not have to convert from one to the other, which introduces an additional opportunity for error. For example, the General Report of the 1960 census of Ghana showed that the questionnaire asked for "age last birthday" because this "could be worked out, if special efforts were made, by recourse to national historical events, local events, family age relationships and other devices, and, as a last resort, looking at the respondent and guessing his age from his physical appearance" (Ghana Census Office, 1964:113). However, in a survey or census in which age reports are frequently based on birth registration cards, work permits, or civil registration books, asking for age instead of birth date requires the respondent or the interviewer to calculate the age from the birth date, which introduces an unnecessary chance for error (Beaujot, 1977:15).

Interviewers and Interviewing Practices

After the decision has been made about which questions to ask and which methods to teach to the enumerators, accurate reporting depends on how well the enumerators conduct the interviews. By comparing the ages stated in transcripts of the tape recordings of Gambian census interviews with the ages recorded by interviewers on the questionnaires, Gibril concluded that 25 percent of the respondents have had their stated ages either over- or understated by interviewers. He emphasizes that these shifts "represent only the differences between the ages estimated at the interview and those recorded by interviewers. They therefore reflect the interviewer's influence in age recording. This influence is quite separate from whatever influence the interviewer already might have had on the age estimated during the interview" (1979:63). After comparing the reported age distribution with a stable model, he concluded that the evidence suggests that "interviewers in recording ages amplify the distortions that are already present in the estimated ages" (1979:69). His study suggests that the enumerators in Gambia were more apt to influence the age of females than males and that they tended to exaggerate the number of women over age 20. He suggests that this bias is almost certainly due to interviewers' reliance on a woman's parity as the basis for estimating her age (1979:69).

Estimating ages in a population of people who have little or no knowledge of their age can be exceedingly frustrating. Any system of estimating ages can break down if the interviewers begin to feel that it does not work or that it is not worth the effort. Gibril reports that interviewers in Gambia tended to avoid the historical calendars because they were difficult to use and respondents were often unwilling to cooperate (1979:36). Scott and Sabagh also found this problem in the first round of the 1961-1962 Multi-Purpose Survey in Morocco (1970:95).

There appears to be a tendency for enumerators to stick to one method of estimating ages. The method they use depends not only on their training, but also on which method they think is the easiest or most reliable. Quandt (1973:56) drew the following conclusion from her studies in Morocco:

> There is some indication that the enumerator's acceptance of the civil registration card or identification card as the correct age depended on the prevalence of cards in the area. Where civil registration cards were rare, there was a hesitancy to break the routine of giving a number by reading a paper. Where cards were numerous, the routine procedure became that of reading the cards.

Scott and Sabagh report witnessing an interview with an educated woman who clearly knew her age, however the enumerator insisted on using an historical calendar to estimate her age. His estimate was off by 15 years because of a confusion between two events (1970:104).

Several WFS surveys have tested the use of an "event chart" to improve the reporting of dates of events by making it easier for the interviewer to discover inconsistencies among reported dates (Scott and Singh, 1980:34-35). By marking each event on a time line, the interviewer can visually check the intervals between births and compare the marriage history and the birth history.

The strength of routine practices and the frustration of constantly facing the problem of getting age estimates is shown clearly in an interview reported by Quandt (1973:122): A woman offers to get her identity card before reporting her age. The interviewer is impatient and demands that she estimate her age. The woman responds, "An estimate is false." The interviewer replies, "That's all, madam. We have a false estimate. We have made an estimate for [your husband]. You must give one for yourself. Estimate and tell us your age." Quandt concludes that "[the enumerator's] task is to fill in a form for each household in his district. . . . His immediate task is to have a number which can be recorded in the blank in front of him. . . . An enumerator's attitude is one of expedience" (1973:54).

Gibril's conclusion about the role of the enumerator is more charitable. He concludes: "On the whole it seems that interviewers do to some extent make an effort to arrive at 'reasonable' ages" (1979:39). In fact, some of Quandt's examples show that the interviewers do attempt to get reasonable estimates, as in the case cited above of the 27-year-old woman with a 13-year-old child.

Although interviewers probably try to get a reasonable estimate of each person's age, they can also have a profound effect on the exact age that is reported. For example, Quandt reports many interviews in which the enumerator suggested possible ages and the respondent merely picked one of the suggested ages (1973:45, 47, 51). In addition, she notes that the enumerators occasionally rounded the numbers that were reported, as in the case of a child who was "not yet a year" being recorded as age 1. The following exchange shows how inflexible enumerators can be (1973:58):

> "How old is your mother?"
> "Forty-six."
> "Forty-five?"
> "Forty-six."
> "Forty-five; forty-five or fifty."
> "Forty-five."

For some reason the interviewer has decided that this woman is not 46 and nothing the respondent says will change his mind.

A careful estimation of ages requires time, flexibility, and patience on the part of interviewers. Training can easily provide a battery of estimation techniques and scheduling can offer time, but flexibility and patience are more difficult to instill in interviewers.

Since a large proportion of age misreporting errors arise through the interview process, the exact causes of errors and their nature depend heavily on the specific characteristics of the population and the survey. In particular, the training of interviewers, their level of education, and their ability to understand and pursue the interests of the researcher will significantly affect the quality of the data. For example, a recent study of the 1973 Tanzanian census results (Ewbank and Hogan, n.d.) shows that the most important factor in determining the smoothness of the age structure was the educational level of the interviewer. (Some other ways in which interviewers influence the quality of the age data collected are discussed in the appendix.) Although many researchers provide anecdotes about the interview process, only Quandt and Gibril provide careful analyses of interviews. These two studies provide us with valuable information, although it is important to recognize that they deal with only two cultures, two censuses, and two sets of interviewers. It is therefore risky to apply their conclusions to other cultures and other surveys. However, their studies and the other research quoted above indicate clearly the wide variety of potential sources of error.

ERRORS INTRODUCED IN DATA PROCESSING

Once the data have been collected they must be processed before analysis can begin. At this stage there are several ways in which errors can be made. First, errors can occur any time the data are transferred from one form to another, for example, during coding or keypunching. In the 1960 U.S. census about 10 percent of the undercount and 40 percent of the overcount were caused by data processing errors (Steinberg, 1966). Second, errors arise when missing values are replaced by statistical procedures, as in attribution of characteristics, or when data-cleaning procedures reject individuals whose characteristics are in fact very different from the norm. A third source of error is the loss of data or the specious inflation of data through double counting of some questionnaires, which is not apt to affect the age distribution because the errors introduced are random. Finally, errors can arise during tabulation of the results.

Although all four of these problems occur in almost every survey, there is little documentation of them. Two studies of data processing errors in the U.S. censuses of 1950 (Coale and Stephan, 1962) and 1960 (Akers and Larmon, 1967) have demonstrated how processing errors can distort analysis even when those errors are very rare. Rare processing errors are most important when they change the reported characteristics of an individual so that he or she moves from a very large category to a small category. For example, in the 1950 U.S. census a slight error in keypunching could turn a white child of the head of the household into a male Indian. Although this error occurred for only about one ten-thousandth of the white children of household heads, it was responsible for the "creation" of 15 percent of the male Indians in the age group 10-14 (Coale and Stephan, 1962:344-5). Similar errors in the 1960 census caused large proportional increases in other numerically small categories. Although this type of problem has rarely been documented, it probably is responsible for some of the reports of very-high-parity women aged 15-19 that appear in many censuses from developing countries. For example, a common keypunching error--typing a "1" in place of a "4," or vice versa--can transform a 47-year-old mother of six into an apparently very precocious 17-year-old.

Another common error that arises during data processing is the confusion of blanks and zeros. Although this is a well-known problem, it still occurs. A similar problem can arise when a code for "unknown" or "not reported" is accidentally included in the open-ended category. For example, this can happen with age when a code of 99 is used to indicate persons whose age is unknown; a simple processing error can include these observations in the last age group, for example, 75 and over.

The best way to reduce the effect of processing errors is to use data-cleaning programs, designed to spot illegal codes and unreasonable combinations of variables. However, despite their efficiency in dealing with large data sets, cleaning programs themselves introduce errors. For example, there may be an 18-year-old woman who has had four live births (perhaps two sets of twins). This is such an unlikely occurrence that a data-cleaning program would undoubtedly either replace her parity with an estimated value or mark the record for reprocessing. In either case this unusual observation might be lost. A drawback of data cleaning is that it eliminates some real cases that are unusual but cannot identify errors that create "typical" cases.

3 Methods for Detecting Errors in Reported Age Distributions

Knowing that an age distribution is distorted and knowing exactly what the distortions are constitute two very different things. There are five basic approaches to detecting distortions in age data. The first is to try to detect errors in individual reports by reinterviewing individuals, possibly using improved age-estimation techniques, or by matching the responses of two independent surveys. A second approach is to compare the age reported by individuals in a survey with the age reported for those individuals elsewhere, for example, to make a case-by-case comparison with civil registers or birth certificates. A third approach is to examine the age distributions of various groups in the population for signs of unexpected differences in their characteristics; for example, one can use age-specific sex ratios to compare the age distributions of the two sexes. A fourth approach is to compare the age distributions reported for the same population in two different censuses. If the population is closed to migration, then the reported size of a cohort at two censuses will reveal changes that are due both to mortality and to relative errors in the two censuses. A final approach is to compare the reported age distribution to an expected distribution. This may mean comparing the distribution with that of an appropriate stable population or simply looking at the smoothness of the age distribution.

Each of these five approaches provides different information about age misreporting. For example, some of the techniques fail to distinguish between age reporting errors (content errors) and errors of undercounting (completeness or coverage errors). They also differ in their degree of sensitivity to content errors. For example, some techniques are sensitive only to net reporting errors, that is, errors that remain after some errors have canceled each other out.

The following discussion reviews the differences between content and completeness errors and between net and gross content errors, then evaluates each of the five approaches to detecting and measuring errors in age distributions.

COMPLETENESS ERRORS AND CONTENT ERRORS

The task of estimating the extent of age misreporting is complicated by the fact that reported age distributions are also distorted by omission (and, less frequently, by double counting) of the populations in various age groups. Often it is difficult to tell the extent of each kind of error. There are several reasons for trying to distinguish between these two problems. First, if we want to improve the survey procedures in future censuses and surveys, it is important to know which sources of error are most critical; second, different kinds of analysis are sensitive to different kinds of errors; and third, techniques for adjusting data are often based on assumptions about the reasons for the errors (for example, van de Walle, 1968).

Table 1 presents estimates of the relative undercounts by age and sex from seven post-enumeration studies in five different countries. It is clear from this table that the reported age distributions from these studies are affected greatly by differences in the completeness of data for different age groups. It appears that there is generally severe undercounting of males aged 15-29 and females aged 15-24, the same groups whose ages might be misreported because of reliance on marital status and parity in estimating of ages. In most of the populations in Table 1 there was relative overcounting (that is, less undercounting) of both sexes over age 35. This would lead to the same kind of age distribution distortions that would be caused by exaggeration of ages of persons over age 25. Since completeness errors like these can be

TABLE 1 Estimated Proportions of Different Age-Sex Groups Omitted from Census Relative to the Overall Undercount: Seven Populations

Age	Korea 1960	Korea 1970	Liberia 1974	Malaysia 1970	Paraguay 1972	U.S. 1960	
						Whites	Non-Whites
Females							
0	--	6.6	3.6	--	--	--	--
1-4	--	-0.8	5.9	--	--	--	--
0-4	1.5	0.7	5.4	0.4	0.7	-0.4	-1.8
5-9	-1.5	-1.7	1.1	-0.4	-2.6	0.0	-3.6
10-14	-0.8	-1.8	-0.7	-0.2	1.1	-0.1	-4.2
15-19	3.3	3.7	3.8	0.6	4.0	0.8	2.2
20-24	4.1	4.6	-0.5	-0.3	7.4	0.8	1.6
25-29	0.2	0.9	-2.8	-0.1	1.2	-0.2	0.7
30-34	-1.9	-1.9	-2.5	-1.4	-1.6	-1.0	-2.4
35-39	-2.3	-2.2	-3.4	-1.8	-4.3	-1.8	-2.1
40-44	-2.9	-2.2	-5.3	-1.9	-3.1	-1.8	-1.8
45-49	-3.4	-2.0	-1.6	-1.1	-5.3	-0.9	0.3
50-54	-2.0	-1.3	-2.5	-0.0	-2.7	2.6	11.0
55-59	-2.5	-2.3	-3.0	0.7	-2.3	0.0	2.1
60-64	-0.7	-0.4	3.8	1.1	-4.6	2.6	6.5
65+	0.0	4.8	-2.6	6.4	-0.3	0.5	4.5
Overall Coverage	95.6	95.0	88.8	96.3	91.6	98.4	91.9
Males							
0	--	3.0	3.6	--	--	--	--
1-4	--	-0.5	0.9	--	--	--	--
0-4	0.6	0.3	1.3	-0.6	0.9	-0.8	-3.6
5-9	-1.6	-2.3	0.4	-1.1	-2.6	-0.4	-5.8
10-14	-2.2	-1.8	0.6	-0.7	-2.6	-0.3	-6.4
15-19	1.2	3.5	6.1	1.2	3.9	1.0	1.8
20-24	5.7	6.6	2.8	2.2	7.1	1.5	7.4
25-29	4.2	4.7	0.4	0.6	6.5	1.4	9.9
30-34	0.7	-1.1	0.1	0.8	0.9	0.3	8.0
35-39	-2.9	-1.6	0.7	-1.0	-1.5	-0.3	4.0
40-44	-4.1	-3.1	-3.5	-1.5	-3.2	-0.9	2.1
45-49	-2.6	-3.3	-3.6	-1.1	-2.6	-1.2	0.7
50-54	-4.1	-3.4	-5.2	-1.4	-6.1	0.8	7.7
55-59	-1.9	-2.4	-7.3	-0.4	-4.2	-2.4	-5.6
60-64	-3.3	-4.3	-3.7	0.4	-0.3	0.2	-1.3
65+	-0.9	8.9	-4.4	4.4	-3.9	1.0	-10.2
Overall Coverage	94.7	95.0	89.2	95.6	90.6	97.2	89.1

Note: The table entries are $1 - [\mu(x)/\mu]$, where μ = overall coverage for the sex and $\mu(x)$ = coverage at age x. A positive value therefore indicates a relative undercount for the age group.

Sources: Korea 1960: Park, 1966. Korea 1970: Unpublished tabulations from the 1970 PES. Liberia: Marks and Rumford, 1978: 191. Malaysia: Chander, 1973. Paraguay: Marks, 1978:177-179. United States: National Research Council, 1972:28.

responsible for distortions similar to those frequently caused by age misreporting, it is important to explore the extent to which the distortions in age distributions might be due to differentials in the completeness of reporting of various age-sex groups.

In examining the impact of content errors on various estimation techniques it is important to distinguish between net and gross errors. Gross errors are the errors made in the individual responses, whereas net errors are the errors in the reported numbers of individuals in each age group after some of the errors have canceled each other out. Some uses of data--for example, stable population analysis--are insensitive to gross errors in age reporting, whereas the Brass techniques for estimating fertility and child mortality might be sensitive to gross errors in age reporting if they are correlated with parity or marital status. In the discussions that follow, we will examine the effectiveness of each of the five main techniques for studying age misreporting, noting the extent to which each method reveals content errors and completeness errors and whether it reveals anything about the gross errors.

POST-ENUMERATION SURVEYS (PES) AND MATCHING OF INDEPENDENT SURVEYS

One approach to testing the validity of ages reported in a census or survey is to send better-trained interviewers, with better tools for estimating ages, to reinterview a sample of the population. By matching the responses from the reinterview with the original census forms it is possible to measure the prevalence of age reporting errors. This can also be accomplished by matching the responses of two independent surveys, which has the advantage of simultaneously producing estimates of both content and completeness errors. Errors of completeness are estimated by looking at the proportion of respondents who were enumerated in only one of the two interviews but should have been interviewed twice. Another advantage of this technique is that it produces estimates of both gross and net content errors.

One of the few large-scale post-enumeration surveys to produce estimates of age misreporting for a national census is the 1960 post-enumeration survey of Ghana. In retrospect it is clear that the sample design was far too

TABLE 2 Comparison of the Age Distributions from the Census and the Post-Enumeration Survey: Ghana 1960

Part A. Comparison of Gross and Net Errors and Age Ratios by Sex

Census Age	Males				Females			
	% Reported in Same Age Group in PES (Gross Errors)	Ratio of PES to Census (Net Errors)	Age Ratio^a		% Reported in Same Age Group in PES (Gross Errors)	Ratio of PES to Census (Net Errors)	Age Ratio^a	
			Census	PES			Census	PES
0-4	86.7	0.99	--	--	86.9	1.02	--	--
5-9	76.0	1.04	115.9	116.4	71.9	0.98	111.4	106.8
10-14	65.5	1.10	89.9	101.3	71.3	1.03	93.5	100.2
15-19	53.4	0.82	80.5	60.1	56.5	0.92	64.5	60.8
20-24	56.3	1.09	82.5	98.2	50.6	0.91	120.4	109.7
25-29	48.3	1.01	116.4	114.8	44.4	1.06	107.9	120.1
30-34	40.5	0.96	106.2	102.9	36.3	0.99	108.6	103.1
35-39	33.0	0.97	95.9	89.6	35.0	1.03	78.6	87.6
40-44	37.9	1.16	94.7	120.2	32.5	0.82	130.2	101.3
45-49	30.2	0.84	104.1	77.8	24.6	1.09	75.4	97.2
50-54	36.5	1.08	105.3	127.3	26.4	0.89	129.2	98.5
55-59	32.8	0.98	92.4	86.8	20.2	1.36	62.6	77.7
60-64	30.8	0.98	101.3	108.8	41.5	1.49	134.0	149.8

Part B. Summary Measures

	Census	PES
Age Ratio Scores[b]		
Males	9.44	14.94
Females	22.27	14.11
Sex Ratio Scores[c]	27.72	20.22
U.N. Combined Scores[d]	114.87	89.71

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[a] The age ratios are 100 times the ratio of the number in the age group to the average of the adjoining age groups.

[b] The age ratio score is the average of the absolute values of the deviations of the age ratios from 100.

[c] The sex ratio score is the average absolute value of the deviations from 100 of the 13 age-specific sex ratios.

[d] The U.N. combined score is three times the sex ratio score plus the two age ratio scores.

Source: Based on Ghana, 1964:391-392.

ambitious; however, despite the numerous difficulties that plagued the matching, the survey did produce estimates of age misreporting. (For a discussion of the problems encountered in running the survey, see Gil et al., 1971:xxi-xxvi.)

Table 2 presents estimates of the net and gross errors in the age reports for individuals recorded and matched in a census and PES in Ghana. For both sexes the proportion of individuals reported in the same five-year age group at both interviews is very low. Of women aged 45-59, less than 25 percent were recorded in the same age group both times. The net errors, however, are not nearly so large. In only four age groups for men and four for women do the net errors reach 10 percent or more.

Table 2 also includes age ratios for the census and the PES age distributions. These ratios compare the population in an age group with the average of the populations in the two adjoining age groups. The age ratios for men show improvements in the PES at only a few ages (10-14 and 20-34), and the overall age ratio score (a measure of the smoothness of an age distribution) is much worse for the PES than for the census. For females, the PES distribution is smoother than the census, however the PES age ratio score for females is still very high. An examination of the sex ratio suggests that the PES is better than the census, although once again the PES score is still very high, 20.22.

The Ghanaian PES shows clearly that the unreliability of the reported ages is exceedingly high; however, it is not clear whether the PES age distribution is really more accurate than the original census distribution. Marks and Waksberg (1960) have come to a similar conclusion for the United States, based on their analysis of the PES of the 1960 census. We will compare the census and PES distributions using some other tests when we discuss the census survival technique for detecting age reporting errors.

Because it appears that the PES approach may be most useful for estimating the unreliability of reported ages, it is helpful to look at measures of the reliability of age reporting derived from several reinterview schemes. Table 3 presents the simplest measure of consistency: the percentage reported in the same five-year age group during two separate surveys. (These comparisons take into account the aging of the population between the dates of the surveys.) Using the average percentage for the age groups 25-49 as an index of overall consistency, we see that the degree of consistency varies from 30 percent for Gambia to about 95 percent for the U.S. in 1960. In every case the consistency of age reporting decreases with age, so that by the age group 30-34 the percentage reporting a different age is at least two or three times as large as at ages 0-4.

The reasons for this decreasing consistency with age are easy to surmise. First, during childhood and adolescence the physiological changes that occur with age are very noticeable and provide valuable clues for estimating age. With increasing age, these visible signs become less precise. Second, since the births of children are much more recent, memories of birth dates and of events that were concurrent with the births are much more apt to be accurate. Third, in many countries the registration of births has increased substantially during the last 30 years and parents of young children are more apt to have birth certificates, which aid in reporting the ages of children.

Table 3 includes two separate estimates of the reporting errors in the U.S. census of 1960. It is useful to note that the estimates from the match with the Current Population Survey almost always indicate more misreporting than does the match with the post-enumeration survey. This finding highlights the fact that even in well-run surveys, the estimates of misreporting are sensitive to the study design, especially the sampling techniques.

Compared with other analytical approaches, such as the census survival techniques and stable population analysis, the PES approach to estimating age misreporting is very expensive. Because of the high costs of the reinterviewing and matching, it is important to weigh these costs against the potential benefits. The values of the process will depend on whether the reinterview is designed solely to estimate the errors in the original interviews or whether it is designed to collect more detailed information to supplement the original survey.

In discussing the benefits of PES studies, Marks (1978:160) has concluded the following:

> While the PES form of dual-system estimation will often give valuable clues on content bias, a PES usually gives adequate measures only for the _variance_ component of content error. That is, in spite of earlier optimism about improving reports of age, income or occupation by doing a more

TABLE 3 Percentage of Persons Enumerated in the Same Five-Year Age Group During a Survey and a Reinterview: Nine Populations

Age in the More Accurate Survey	Medical Research Council, Gambia[a]	Ghana 1960[b]	Rawalpindi, Pakistan 1971	Korea 1960	World Fertility Survey Indonesia Females[c]	Nigeria 1973-74	U.S. 1950	U.S. 1960		U.S. 1970
								Reinterview	Current Population Survey	
0-4	89	86.0	80	94	--	--	97.0	98.2	96.4	93.1
5-9	81	73.0	73	92	--	--	97.9	97.6	96.1	96.1
10-14	66	65.0	69	90	--	--	96.9	98.1	96.6	96.1
15-19	57	63.5	63	89	93	77	97.0	96.8	95.5	95.8
20-24	41	54.0	53	90	90	60	95.3	96.2	93.3	94.6
25-29	42	45.0	52	89	92	40	94.3	97.5	95.0	94.0
30-34	36	39.5	41	89	85	27	93.2	95.9	93.3	91.3
35-39	24	34.0	34	86	88	41	93.4	95.4	93.2	91.2
40-44	28	36.5	30	88	79	24	92.4	92.9	92.8	91.5
45-49	19	29.5	36	86	81	28	90.5	92.8	93.6	92.5
50-54	33	32.0	29	87	--	--	89.5	92.8	89.4	92.1
55-59	20	24.5	10	87	--	--	88.9	94.9	90.2	91.8

60-64	30	29.5	32	--	--	--	91.5	89.5	90.4	89.6
65-69	8	27.5	7	--	--	--	91.0	93.5	94.2	88.0
70-74	24	30.0	39	--	--	--	90.7	89.6	88.4	91.3
75+	58	63.0	47	--	--	--	94.5	93.6	90.1	94.0
Average for 25-49	29.8	36.9	38.6	87.6	85.0	32.0	92.8	94.9	93.6	92.1

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[a] Under age 22, the match compares the census with the birth registration system organized by the Medical Research Council. Over age 22, the match is with the year of birth derived from annual surveys during the previous 22 years.

[b] Average of the values for the two sexes.

[c] These percentages compare the original age report with the best age estimate after interviews to reconcile differences between the original interview and the reinterview. Therefore, they differ from the published results, which compare the original interview with the reinterview.

Sources: Gambia: Gibril, 1979. Ghana: Ghana, 1964:389. Rawalpindi: Kenya, 1976:12. Korea: Park, 1966. Indonesia: Unpublished tabulations. Nigeria: Andoh, 1980:8. U.S. 1950: U.S. Bureau of the Census, 1960:27. U.S. 1960: U.S. Bureau of the Census, 1974:10 and 1975a:9. U.S. 1970: U.S. Bureau of the Census, 1975b:21.

> intensive interviewing job, PES reports of these characteristics are usually not better than census reports.

He therefore recommends that these surveys be designed to maximize the information gained about completeness.

There are several factors that will affect the likelihood that a PES can produce better age estimates. First is the quality of the original interviews, which can be judged by the training given to the interviewers, the techniques at their disposal (for example, did they have properly prepared historical calendars), the time allotted for each interview, and the amount of careful supervision.

A second consideration is the population's awareness of ages. If the population has little or no awareness of age (for example, if there are reports of 25-year-old grandmothers), then a reinterview using more elaborate interviewing techniques might improve the reporting.

A third factor that affects the value of a PES is the quality of the matching. A low proportion of matches greatly reduces the reliability of the results. Therefore the potential benefits will depend on the availability of good information for matching.

Marks has concluded that PES studies usually provide only a good measure of the variance of the content error. This suggests that frequently the results of a PES will not be very useful for adjusting the data prior to analysis, since such an adjustment requires estimates of the biases in reported ages. For example, adjusting age data before applying stable population analysis requires an estimate of the net errors. For some types of analysis, even more information is needed; for example, adjusting individual observations for use in analyzing differences among individuals requires information about gross errors and adjusting the data prior to applying the Brass techniques for estimating fertility and mortality requires information about the characteristics of those who report age incorrectly. Unless the results of reinterviews can be regarded as correct, they will prove to be of little value in adjusting the data prior to the application of such analytical techniques.

In most circumstances, when the ages reported in the PES suffer from errors similar to those of the initial enumeration, the PES data will provide little more than an estimate of the variance of age reporting, and this estimate itself provides a lower bound for the true variance, because of the tendency for respondents to give the same answer twice. For some purposes, however, it is useful to have an estimate of the variance of age responses, since such an estimate can provide a warning when applying multivariate techniques at the level of the individual. If the variance of age responses is high, the conclusions that can be drawn from the data are severely restricted. Most studies of age misreporting show a rather large random component in age reports, suggesting that caution should be exercised in analysis at the individual level.

Marks's conclusion that PES surveys should concentrate on estimating the completeness of censuses appears to be justified. The question then becomes: Can the cost of PES studies be justified primarily on the basis of the information they provide about errors of completeness? Since results of PES studies in Liberia and Paraguay showed overall undercounts of about 10 percent, the magnitude of coverage errors is probably a major problem. Comparisons in the U.S. of coverage errors estimated from PES studies and those derived from analytic estimates show that there are major discrepancies between the two approaches (Siegel and Zelnick, 1966). However, analytical methods for estimating coverage errors are not very reliable unless there is reasonably accurate information available on fertility, mortality, and migration rates--and such data are often lacking in developing countries. For this reason, PES surveys may provide the only reliable approach to estimating coverage errors in developing countries. Moreover, because many of the techniques for estimating fertility, mortality, and migration rates rely on the assumption that censuses provide complete coverage, estimates of coverage errors are especially important in dealing with data from many developing countries.

COMPARISON OF SOURCES

Several studies of age misreporting have been based on the comparison of ages reported in different record systems. For example, ages reported in censuses or surveys have been compared with those shown on birth certificates or baptismal records (Caldwell, 1966; Gibril, 1975; Raghavachari and Natarajan, 1974; Chari, 1977; Murray, 1979; Pison, 1978; U.S. Bureau of the Census, 1953), death certificates (Great Britain, 1970; U.S. Public Health Service, 1968), and Medicare records (U.S. Bureau of the Census, 1973). Like the reinterview procedure, the record-comparison approach sometimes produces reliable estimates only of the variance of the age reports, since it is often unclear which of the two sources is more accurate. Obvious exceptions are birth certificates and baptismal records, which are generally reliable if the event was in fact recorded shortly after it occurred.

Numerous recent studies demonstrate that even in societies where most births are not recorded, birth or baptismal records can be used for testing the accuracy of reported ages. In Murray's study in Haiti (1979), dates on baptismal records were combined with relative ages in the community to produce estimates of each person's age, which were then compared with reported ages based on an events calendar. In Caldwell's study of Ghana (1966), a sample of children aged 0-8 whose births had been recorded were interviewed to assess the accuracy of age reporting. The Census Evaluation Study of the 1971 census in India used birth registration records in the Sample Registration System to cross-check census reports. The studies of Gambia and Senegal by Gibril (1975) and Pison (1978) compared a census or a survey with data collected during previous longitudinal studies.

If we are to produce better estimates of the biases in age reporting in developing countries, it will be important to find situations in which birth records or baptismal records can be used to measure directly the errors in reporting. In any country there are some births that are recorded, and even if these records are not representative of the whole population, they may still provide the best tool for measuring the degree and nature of age misreporting.

CROSS-TABULATING BY AGE TO IDENTIFY AGE MISREPORTING

Another common way of detecting and measuring age misreporting is to examine the age-specific sex ratios of the enumerated population, which are included in the sex ratio score recommended by the United Nations (1955). This index is the sum of the absolute values of the successive differences in the sex ratios between age groups for five-year age groups from age 0 to 69. In the absence of sex-selective migration and undercounts, this index provides a measure of the net errors in age reporting only to the extent that the patterns of misreporting differ for the two sexes. For example, this method probably fails to give accurate estimates of age misreporting among children aged 0-4, because reporting errors in this age group are apt to be similar for the two sexes.

One problem with the sex-ratio test for age misreporting is that it cannot distinguish between deviations due to age misstatement and deviations due to sex-selective under- or overreporting. An example of this is given in Table 4, which shows the sex ratios for the 1972 census of Paraguay. The reported age distribution leads to a sex ratio score of 4.54, which suggests reasonably accurate reporting. Table 4 also presents age ratios based on the age-sex distribution after it has been adjusted for the estimated undercounts for each age-sex group, as determined by the post-enumeration survey. This adjustment reduces the sex ratio score from 4.54 to 3.92. The biggest improvement in the sex ratios comes at ages 25-29, where the ratio is increased from 93.1 males per 100 females to 99.5 per 100 females.

A second use of simple cross-tabulations was demonstrated by Goldman et al. in their study of the Nepal Fertility Survey (1979). They discovered evidence of the effects of age misreporting by looking at tabulations of parity and marital status by single years of age. For example, they present the following table of the percentage of women ever-married by age (1979:12):

Age	18	19	20	21	22
% Ever Married	77.7	81.1	92.8	89.2	94.4

The relatively high proportion ever married at age 20 as compared with age 21 clearly suggests that ever-married women who are 18 or 19 are sometimes being reported as 20 years old and that single women aged 20 may be being reported as 19.

Similar data are available from the Deschapelles area of rural Haiti. Data from a four-year prospective study by Berggren et al. (1974, 1979) provide the following distributions of age at entry into first marriage and of the proportion ever married.

TABLE 4 Age and Sex Ratios for the 1972 Paraguayan Census, With and Without Adjustments for Age-Selective Underenumeration

	Reported Age Distribution			Age Distribution Adjusted for Undercount[a]		
	Sex Ratio (males per 100 females)	Age Ratios		Sex Ratio (males per 100 females)	Age Ratios	
Age		Males	Females		Males	Females
0-4	103.4	--	--	104.8	--	--
5-9	103.5	103.1	104.2	104.6	101.2	100.7
10-14	106.0	107.3	102.9	103.3	104.4	103.7
15-19	99.0	99.8	102.7	99.9	102.7	103.1
20-24	95.2	92.1	93.7	95.9	94.3	98.1
25-29	93.1	92.3	95.2	99.5	94.2	92.5
30-34	97.0	102.4	97.3	100.6	99.8	96.7
35-39	91.0	87.8	94.3	94.5	87.3	92.5
40-44	98.4	114.7	106.6	99.3	113.4	108.4
45-49	92.1	91.3	96.8	95.8	92.8	94.4
50-54	96.5	109.5	104.3	94.5	106.6	105.8
55-59	91.6	88.8	90.8	90.9	88.5	91.8
60-64	89.2	110.5	108.3	94.0	114.7	105.1
65-69[b]	81.0	85.7	94.4	79.1	83.8	97.0
Mean Absolute Deviation from 100	4.54	8.44	5.12	3.92	7.87	4.91
U.N. Combined Scores[c]	Reported:	27.18		Adjusted:	24.54	

[a] Adjustment based on the results of the post-enumeration survey, from Marks (1978:175-177).

[b] The adjustment for the undercount at 65-69 is based on the value for 65 and over.

[c] The U.N. combined score is three times the sex ratio score plus the two age ratio scores. (See Table 2 for definitions.)

Age	18	19	20	21	22
% Entering First Marriage	2.4	7.8	12.0	11.0	11.0
% Ever Married	27.3	14.0	35.1	41.2	45.5

These data also reflect age distortions that are related to marital status.

Goldman et al. have also compared tabulations of parity by single years of age to a curve of cumulated age-specific fertility rates reported in the same survey of Nepal (1979:22-24). This analysis suggests that the exaggeration of age at the younger ages is related to parity and that at the older ages of childbearing women who are unsure of their age are also apt to underreport their parity. In Table 5, the average parities and deviations from the synthetic cohort in Nepal are compared to similar values for a sample of 1,333 women from the Ashanti region of Ghana, which was selected from the 1971 Supplemental Enquiry data. Because the cumulated "births in the last year" in the Ghanaian data show evidence of underreporting, we have calculated deviations from a three-year moving average of the differences to show more clearly the age selectivity of misreporting of parity. In general, the Ghanaian data show the same pattern as those from Nepal: relatively high reported parity at ages 20 and 25 and relatively low reported parity at ages 40 and 45.

Table 5 also presents data for the women of the Ashanti region on the reported proportion of their children who are now deceased. These data show no evidence of unusually large selective omission of deceased children among women whose ages are reported as 35, 40, or 45. This suggests that the older women of childbearing age, whose ages are heaped due to lack of knowledge of age, have underreported the number of children they have borne, both living and deceased. This is also consistent with the data from Nepal (Goldman et al., 1979:24).

The tests used by Goldman et al. on the Nepal data, and repeated here on the data from Haiti and Ghana, provide an interesting model for the use of cross-tabulations by age to understand misreporting of both age and parity. The techniques provide some information about the nature of the gross errors that

TABLE 5 Comparisons of Reports of Average Parity and Births in the Last Year by Single Year of Age: Nepal 1976 and Ghana 1971

	Nepal		Ashanti Region, Ghana			
					Difference in Parity from Synthetic Cohort (F-P)	
Age	Reported Average Parity (F-P)	Difference in Parity from Synthetic Cohort[a] (F-P)	Reported Average Parity (P)	Percentage of Children Deceased	Reported[a]	Smoothed[b]
15	0.01	0.04	0.02	0.0	-0.01	--
16	0.04	0.08	0.07	10.0	0.00	0.01
17	0.17	0.07	0.22	6.8	-0.03	0.00
18	0.31	0.08	0.45	8.1	-0.07	-0.02
19	0.53	0.07	0.65	8.6	-0.06	0.06
20	0.91	-0.05	1.11	10.7	-0.23	-0.04
21	1.12	-0.01	1.45	12.7	-0.29	-0.02
22	1.45	-0.03	1.72	11.1	-0.28	0.03
23	1.66	0.11	2.06	12.7	-0.36	0.00
24	1.88	0.20	2.41	12.7	-0.44	0.03
25	2.53	-0.13	2.84	13.3	-0.60	-0.06
26	2.66	0.09	3.07	13.8	-0.58	0.04
27	2.87	0.16	3.46	15.9	-0.67	0.02
28	3.01	0.31	3.91	15.6	-0.83	-0.08
29	3.65	-0.07	4.08	15.7	-0.75	0.14
30	3.70	0.15	4.66	17.3	-1.09	-0.17
31	3.91	0.23	4.81	15.7	-0.93	0.13
32	4.19	0.22	5.33	17.8	-1.16	-0.12
33	4.70	-0.03	5.45	18.6	-1.04	0.10
34	4.70	0.21	5.84	19.3	-1.22	-0.08

35	4.65	0.44	6.00	19.7	-1.15	0.01
36	4.86	0.43	6.16	18.6	-1.10	0.05
37	5.26	0.24	6.46	21.0	-1.21	-0.02
38	5.38	0.31	6.71	20.3	-1.27	0.01
39	5.60	0.26	6.94	19.0	-1.37	-0.15
40	5.20	0.75	6.71	22.2	-1.02	0.15
41	5.86	0.20	6.91	22.4	-1.13	0.01
42	5.47	0.68	7.13	24.0	-1.26	0.10
43	6.03	0.17	7.65	25.4	-1.70	-0.21
44	5.80	0.46	7.55	25.2	-1.51	-0.18
45	5.25	1.04	6.88	23.5	-0.78	0.27
46	5.87	0.45	6.99	20.4	-0.86	0.06
47	6.00	0.34	7.29	24.1	-1.12	-0.21
48	5.83	0.52	6.93	24.6	-0.75	0.34
49	6.36	0.01	7.59	22.7	-1.40	

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[a] Deviations of the reported parities (P) from the cumulated age-specific fertility rates (F) are based on reports of births in the previous year.

[b] Deviation of the differences from three-year moving average of reported differences.

Sources: Nepal: Goldman et al., 1979:23. Ghana: Unpublished data from the Ghana 1971 Supplemental Enquiry.

underlie the more obvious net errors, and the single-year cross-tabulations might reveal evidence of misreporting even when the reported age distribution in five-year age groups does not appear to be affected by misreporting.

ANALYZING COHORT SURVIVAL RATES

If we study a birth cohort, the change in the size of the cohort as measured at two censuses ideally should be due only to mortality and migration. In fact, the reported counts will also be affected by the content and completeness errors in the two censuses. Therefore, it is possible to estimate the extent of these errors by adjusting the proportion surviving between censuses for mortality and migration. The resulting ratio should be very close to 1.0, if the adjustments are correct and there are no reporting errors.

The use of census survival rates to estimate the errors in consecutive censuses is best exemplified by the work of Coale and Zelnick (1963) and Coale and Rives (1973) for the population of the United States. These studies have provided both revised age distributions and revised estimates of fertility for more than a century of American history.

The potential usefulness of census survival rates for studying age misreporting in developing countries is illustrated in Table 6, which presents estimates of errors in nine censuses of India. These figures are based on population figures for ages 0-29 for the areas that were included in all nine of the decennial censuses of India from 1881 to 1961 (Mukherjee, 1976:63). The numbers shown are the result of dividing the census survival ratios by the survival ratios implied by life tables with life expectancies similar to those estimated by Mukherjee for each period. Because the population of India has been affected only slightly by external migration during most of the period, the resulting ratios should be pure indexes of errors in the reported age distributions.

The surprising result in Table 6 is the constancy of these ratios over the eight decades. The average of the ratios for the first three periods is very similar to the average for the last three periods. For most age groups this constancy is more apt to be due to a constant pattern of age misreporting than to a constant pattern of relative undercounts, although both certainly add to the pattern.

TABLE 6 Census Survival Ratios Divided by Appropriate Life Table Survival Ratios for Children and Young Adults in the Indian Censuses of 1881-1961: Areas Common to All Nine Censuses

Date of Earlier Census	Age at Earlier Census							
	Males				Females			
	0-4	5-9	10-14	15-19	0-4	5-9	10-14	15-19
1881	1.01	0.72	1.14	1.58	1.32	0.72	0.83	1.41
1891	1.01	0.68	1.14	1.42	1.27	0.70	0.81	1.31
1901	1.09	0.71	1.04	1.44	1.36	0.73	0.79	1.32
1911	1.03	0.65	1.01	1.33	1.29	0.69	0.76	1.23
1921	1.07	0.69	1.05	1.50	1.33	0.71	0.80	1.37
1931	1.07	0.69	1.02	1.36	1.31	0.70	0.82	1.28
1941	1.13	0.76	1.01	1.35	1.25	0.77	0.83	1.33
1951	1.08	0.81	0.98	1.26	1.23	0.84	0.85	1.21
Average of First Three Ratios	1.04	0.70	1.11	1.48	1.32	0.72	0.81	1.35
Average of Last Three Ratios	1.09	0.75	1.00	1.32	1.26	0.77	0.83	1.27

Note: The values shown are

$$\left[\frac{P_{10}\ (10\text{-}14)}{P_{0}\ \ (0\text{-}4)}\right] \div \left[\frac{{}_{5}L_{10}}{{}_{5}L_{0}}\right]$$

where P_t(10-14) is the population aged 10-14 at time t and L values are taken from the appropriate life tables for the population. Therefore, values greater than 1.00 suggest a relative overcount of the cohort at the later census; those less than 1.00 suggest a relative undercount.

Source: Based on Mukherjee, 1976:63.

Although the census survival approach can be applied to two censuses, its value increases when three or more age distributions can be compared. Countries that have a well-established tradition of census taking can take special advantage of this technique. For example, Demeny and Shorter's analysis (1968) of the age distributions from the censuses of Turkey between 1935 and 1960 shows clearly that the distortions in the reported age distributions remained constant over this period. Using census survival techniques, they produced estimates of the pattern of misreporting and corrected the age distributions. The corrected distributions then revealed variations in cohort size that could be explained in terms of historical events that probably affected the growth of the population. A more detailed analysis for the period 1950-60 produced similar results (Ntozi, 1978).

A similar study of the age distributions of Tunisia--as reported in the censuses of 1946, 1956, and 1966 and in the National Demographic Survey of 1968 (Picouet, 1969)--demonstrated that some of the apparent distortions in the reported age distributions were due to real differences in cohort size caused by the effects of World War II on fertility and mortality.

It is important to note that the assumption of a constant pattern of age misreporting in a given population is not always justified. Although the evidence from India, Turkey, and the United States demonstrate that misreporting patterns can remain constant over relatively long periods, changes in the patterns do occur. For example, Krotki and Beaujot have noted differences in age reporting errors among Moroccan censuses (1975:347).

The results from census survival studies can be compared to estimates of net reporting errors from post-enumeration surveys. In particular, it is useful to test the results from the 1960 PES of Ghana by comparing the reported age distributions from the 1960 and 1970 censuses. Because of the effect of migration on the Ghanaian population during the decade, one must limit the comparison to the census survival rates of the native-born population. Unfortunately, the age distribution of the native-born is available for only five age groups in the 1960 census (Ghana, 1962:13): 0-4, 5-14, 15-24, 25-54, and 55 and over. This division merges two age groups that are of prime importance for numerous studies: the 15-19 and the 20-24 groups.

Table 7 presents the census survival rates, the life table survival rates, and the survival rates adjusted for mortality during the period. These rates adjusted for mortality differ substantially from 1.0, indicating extensive reporting errors or remaining effects of migration. Because the rates for two of the age cohorts are less than 1.0, and one cohort has rates substantially

TABLE 7 Ten-Year Census Survival Rates for the Native-Born Population of Ghana, Adjusted for Mortality and Estimated Age Reporting Errors

Age at First Census	Census Survival Rate	Life Table Survival Rate[a]	Census Survival Rate ÷ Life Table Survival Rate	Census Survival Rates Adjusted by 1960 PES	
				1960 Census Only	Both 1960 and 1970 Censuses
Males					
0-4	0.803	0.914	0.879	0.884	0.938
5-14	0.805	0.943	0.854	0.805	0.762
15-24	1.051	0.926	1.135	1.200	1.183
Females					
0-4	0.747	0.918	0.814	0.798	0.799
5-14	0.912	0.947	0.963	0.962	0.880
15-24	1.117	0.938	1.190	1.301	1.336

[a] From Coale-Demeny model life tables, "North" level 12.

Source: Based on data from Ghana (1962:13; 1964:403; 1975:52).

greater than 1.0, migration is unlikely to have played an important role in these distortions.

In order to test the usefulness of the PES for explaining these survival rates, we first adjusted the 1960 age distribution according to the PES estimates of net errors in age reporting. This adjustment slightly improved only one of the survival rates (males aged 0-4). The largest effect was on the oldest cohort, for which the ratio of the survival rate to the life table rate was made even larger. The second adjustment for age misreporting was to apply the error estimates from the 1960 PES to the 1970 census figures as well, on the assumption that the pattern of misreporting was probably very similar for the two censuses. These adjustments improved the rates for only one cohort substantially (again, males aged 0-4), while most of the rates were moved farther from a value of 1.0.

These tests suggest that estimates of the net errors in age reporting from the 1960 census of Ghana provide little help in adjusting the age distribution. Although estimates for some of the five-year age groups probably would have performed better, it is unlikely that they would have been able to improve the age distribution appreciably.

There are two possible reasons why these adjustments did not succeed. The first is that the PES probably did not result in improved estimation of ages; estimates of net reporting errors may provide little or no information on the real biases in age reporting. A second reason is that the PES did not produce useful estimates of coverage errors. It is possible that the coverage errors were substantial and may have differed substantially for different age-sex groups. For example, in the 1968-69 National Demographic Sample Survey of Ghana, the two rounds were compared to estimate the coverage errors. This comparison demonstrated that the males and females aged 15 and over were underenumerated by 26 and 15 percent, respectively (Gaisie, 1976:68). Although Gaisie concluded that the sample survey had poorer coverage than the censuses, it is clear that substantial coverage errors that differ by age and sex are possible causes of the distortions in the 1960-70 census survival rates.

The 1970 and 1980 census rounds provide second and third censuses for many countries, thereby increasing the number of populations to which the census survival techniques can be applied. These techniques are also useful for combining reported age distributions and PES estimates of underreporting to isolate errors that are apparently caused by age misreporting.

STABLE POPULATION ANALYSIS

One of the most valuable tools for studying errors in reported age distributions is to compare them with model populations that reflect the best guess about demographic trends in the population. Until recently, stable population analysis was one of the few techniques widely applicable to developing countries. During the 1960s and 1970s, many new countries had their first census and many of them had experienced only moderate declines in mortality and no decline in fertility in recent decades. These conditions made it possible, and to some extent necessary, to estimate errors in age reporting by comparing stable population models to single censuses.

Comparing a population's reported age distribution to a stable model is far from ideal as a method for estimating age misreporting because it cannot distinguish between content and coverage errors (Krotki, 1969) and it is affected by migration and fluctuations in fertility and mortality (Keyfitz, 1966). However, numerous studies based on this approach have shown that distortions in age distributions tend to follow patterns that appear in widely differing cultures.

To demonstrate the usefulness of the stable population approach, we applied it to the age-sex distribution from the 1972 census of Paraguay. In addition, we applied the same technique to the census data after adjusting for the age-sex selective undercounts, estimated from the post-enumeration survey. This allows us to evaluate the relationship between the stable population estimates of distortions and the PES estimates of distortions due to selective undercounts.

We used two indexes to measure how closely the data fit the stable model. The first index is the sum of the squared deviations of the actual proportion in each age group from the fitted stable model values; the smaller the value of that index the better the fit. The second index compares the differences between the crude birth rates (CBR) estimated using a stable model and the proportions under each fifth age from 5 to 45. If the population had really been stable and if the age distributions were reported correctly, all nine estimates of the CBR should be equal. As an index of variability we used the CBR mid-range: the difference between the third-highest CBR estimate and the seventh-highest CBR estimate.

Table 8 presents the results of this analysis. It is clear from the table that the adjustment for the PES estimate of the undercount greatly improved the fit of the male population to the stable model. There are small improvements for many age groups, and both overall indexes improved noticeably for the males. However, the fit of the female population showed little or no improvement. It therefore appears that, at least for Paraguay, the age selectivity of the undercount distorts the age distribution of males more than it does that of females. It also appears that the undercount was the reason that the reported age distribution for males produced less-consistent estimates of the CBR than was the case for females.

In addition, it is worth noting that for both males and females the adjustment for the undercount improved virtually every age group except 0-4 and 15-19. However, since large deviations persist in many age groups, it appears that age misreporting must be the prime source of errors in many age groups.

TABLE 8 Stable Population Analysis of the Reported and Adjusted Age Distributions: Paraguay 1972

	Reported by Census					Adjusted for Undercount				
Age	c(a)	C(a)	CBR	Stable c(a)	c(a) ÷ Stable c(a)	c(a)	C(a)	CBR	Stable c(a)	c(a) ÷ Stable c(a)
Males										
0-4	16.00	16.00	37.86	17.26	0.93	16.14	16.14	38.23	17.63	0.92
5-9	15.67	31.67	41.17[a]	14.42	1.09	15.27	31.41	40.75	14.65	1.04
10-14	14.40	46.07	44.11	12.29	1.17	14.03	45.44	43.24	12.41	1.13
15-19	11.17	57.23	44.85	10.46	1.07	11.62	57.06	44.63	10.51	1.11
20-24	7.98	65.22	43.76	8.85	0.90	8.59	65.64	44.31	8.84	0.97
24-29	6.17	71.38	42.08	7.47	0.83	6.60	72.24	43.29	7.42	0.89
30-34	5.37	76.75	40.75	6.28	0.86	5.42	77.66	42.17[a]	6.21	0.87
35-39	4.33	81.08	39.33	5.26	0.82	4.26	81.92	40.62	5.18	0.82
40-44	4.48	85.57	39.18	4.38	1.02	4.34	86.26	40.43	4.29	1.01
CBR Mid-range:			4.43					2.67		
Sum of Squared Deviations from 1.0:					0.138					0.099

Females										
0-4	15.21	15.21	35.30	16.32	0.93	15.31	15.31	35.56	16.80	0.91
5-9	14.88	30.09	38.14	13.80	1.08	14.50	29.81	37.70	14.11	1.03
10-14	13.36	43.45	40.05	11.87	1.13	13.51	43.32	39.89	12.05	1.12
15-19	11.09	54.54	41.01	10.21	1.09	11.56	54.87	41.43	10.30	1.12
20-24	8.24	62.78	40.37	8.74	0.94	8.90	63.78	41.62	8.75	1.02
25-29	6.51	69.30	39.29	7.45	0.87	6.59	70.36	40.63	7.41	0.89
30-34	5.44	74.74	38.20[a]	6.35	0.86	5.35	75.72	39.46[a]	6.27	0.85
35-39	4.68	79.42	37.19	5.39	0.87	4.49	80.21	38.33	5.29	0.85
40-44	4.48	83.90	36.91	4.55	0.98	4.35	84.55	37.99	4.43	0.98
CBR Mid-range:			2.86					2.64		
Sum of Squared Deviations from 1.0:					0.094					0.096

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[a] These are the median CBR estimates, used to determine the stable fit. The model life table used is Coale-Demeny "West" level 17.

Source: Based on Marks (1978:177-179) and U.N. Demographic Yearbook (1975:236-237).

TABLE 9 Stable Population Analysis of the Reported and Adjusted Age Distributions: Liberia 1974

	Reported by Census				Adjusted for Undercount			
Age	c(a)	C(a)	CBR	c(a) ÷ Stable c(a)	c(a)	C(a)	CBR	c(a) ÷ Stable c(a)
Males								
0-4	15.18	15.18	39.77[a]	1.00	15.39	15.39	40.39	0.99
5-9	15.10	30.28	43.93	1.18	15.16	30.55	44.43	1.16
10-14	11.53	41.81	43.30	1.01	11.60	42.14	43.80	1.00
15-19	9.96	51.77	42.71	0.98	10.60	52.75	44.07	1.03
20-24	7.18	58.94	40.30	0.80	7.38	60.13	41.83	0.82
25-29	7.08	66.02	39.35	0.90	7.11	67.24	40.90[a]	0.91
30-34	6.21	72.22	38.45	0.91	6.21	73.45	40.13	0.92
35-39	6.24	78.46	38.81	1.06	6.20	79.65	40.63	1.07
40-44	4.76	83.22	38.14	0.94	4.60	84.24	39.98	0.93
CBR Mid-Range:			4.53				3.41	
Sum of Squared Deviations from 1.0:				0.098				0.083
Females								
0-4	15.11	15.11	38.52	0.93	15.98	15.98	40.95	0.94
5-9	14.69	29.80	41.95[a]	1.09	14.86	30.83	43.78[a]	1.07
10-14	10.18	39.99	39.70	0.87	10.12	40.95	41.09	0.84
15-19	11.22	51.20	41.18	1.10	11.66	52.61	43.04	1.13
20-24	9.01	60.21	41.41	1.02	8.97	61.58	43.20	1.01
25-29	8.99	69.20	43.28	1.18	8.75	70.33	44.87	1.16
30-34	7.74	76.95	45.38	1.19	7.56	77.88	46.92	1.18
35-39	6.17	83.12	47.12	1.12	5.97	83.86	48.52	1.11
40-44	4.15	87.27	46.95	0.89	3.94	87.79	48.13	0.87
CBR Mid-Range:			4.20				3.88	
Sum of Squared Deviations from 1.0:				0.135				0.138

[a] These are the median CBR estimates, used to determine the stable fit. The model life table used is Coale-Demeny "West" Level 11.

Source: Based on Marks and Rumford (1978:190-191) and U.N. Demographic Yearbook (1978).

Table 9 presents the same type of analysis for the 1974 census of Liberia, with adjustments based on the estimates of underenumeration from the PES. The results of this analysis are similar to those for Paraguay. Adjusting for underenumeration increased the consistency with the stable model for both the male and female age distributions. Once again, the improvement in the fit for the males was more substantial than that for the females, reducing the mid-range of the CBR estimates by more than one point. This suggests that age-selective underenumeration is a more important source of error for males than it is for females. As in the Paraguay case, the adjustment for underenumeration increased the difference between the reported distribution and the stable model for females 15-19 and had the same effect on females 10-14. For males 15-19, the adjustment reversed the relationship between the reported distribution and the stable, raising the reported value from 2 percent below the stable to 3 percent above it.

There is one further similarity between these two populations. In both cases, adjusting the distribution increased the median estimate of the CBR (which was used to determine the age distribution) by at least one point for both sexes. The main reason for this is the fact that in both cases the estimates of the degree of undercount are lower for ages over age 35. This relatively low underenumeration over age 35 was seen in Table 1, which showed this to be a feature of all the populations for which such estimates are available. This conclusion supports the fears expressed by Krotki (1969:9) that the methods recommended in U.N. Manual IV for estimating fertility rates from stable age distributions might lead to underestimation of fertility because of age-specific underenumeration.

Although both the Liberian and the Paraguayan age distributions were apparently improved by making adjustments for the estimated underenumeration, there were still significant differences between the reported and the stable distributions. These differences are probably due to age misreporting, although some of the distortion probably is caused by undetected underenumeration and real deviations from stability.

4 Typical Patterns of Distortion in Reported Age Distributions

Although age misreporting and the age selectivity of content errors are clearly related to the design of the survey, the training of the interviewers, and the cultural environment of the population, there are common patterns of distortions that are found in censuses and surveys conducted in widely differing settings.

During the last 15 years, studies in developing countries have produced extensive information about these patterns and the reasons for them. One of the most comprehensive studies was carried out at the Office of Population Research at Princeton under the direction of Ansley Coale and Paul Demeny. This research was based on stable population analysis of more than 150 age-sex distributions from censuses or surveys of populations thought to be approximately stable (United Nations, 1967:17-23). These studies led to the discovery of two basic patterns of distortion. The first pattern is typical of populations in Africa and Southern Asia, while the second is typical of Latin America. The so-called African pattern is characterized by "a systematic form of unidirectional age-misreporting over a broad range" which even distorts the cumulated age distribution (United Nations, 1967:19). The Latin American pattern "causes pronounced age heaping by single years, the distribution by five-years tends to alternate excesses and deficits, and the cumulative distribution is not much distorted."

The African pattern of distortions for females is characterized by "a surplus at 5-9, and a deficit in the adolescent age intervals (10-14 and 15-19), followed by a surplus in the central ages of childbearing (25-34)" (United Nations, 1967:19). For males, the distortions appear to be larger and there are fewer similarities between the patterns for various countries. Coale and Demeny concluded that these distortions have three major causes: (1) a tendency to exaggerate the ages of children 0-4, (2) a tendency to exaggerate the ages of girls 10-14 if they have passed puberty and to understate the ages of those who have not reached puberty, and (3) a tendency to exaggerate the ages of women 15-29, probably to make their ages consistent with expectations regarding age at marriage and fertility.

The Latin American pattern is much simpler and generally involves preference for the age groups 25-29 and 35-39 over the groups 30-34 and 40-44. There also seems to be a general surplus of women reported at 20-29. Unlike the African pattern, the male Latin American pattern seems to be less distorted than the female (United Nations, 1967:21).

The patterns of distortions in age reports discovered through stable population analysis provide valuable information that can help researchers recognize distortions due to age misreporting and content errors. Moreover, these patterns give us some confidence that studies of distortions in particular populations may apply to other populations. However, this approach cannot provide detailed knowledge of the reasons for the distortions and it provides little information about the impact of misreporting on analytical techniques other than stable population analysis. It also fails to distinguish between distortions in the reported age distribution that are caused by misreporting and distortions due to age-selective omission rates.

It is useful to note that even random errors, which are themselves unbiased, can introduce distortions into an age distribution. Recording errors for the young cannot be unbiased, because of the impossibility of recording a negative age, but a normally distributed error term beginning at some age such as 10 will tend to reduce the size of large age groups and inflate small ones. In any population with a basically triangular age distribution, such as a stable population with a positive growth rate, an error term that is normally distributed after childhood and of constant standard deviation will inflate the population at each age, giving rise to an impression of age exaggeration. This effect, however, is extremely small. For example, in a stable population with a growth rate of 2.5 percent per year and an expectation of life at birth of 57.5 years, a normally distributed error with a standard deviation of three years affecting the entire reporting population would inflate the population aged 20 by 0.29 percent and the population aged 70 by 0.47 percent. These biases, which from a practical point of view are unimportant, would be increased somewhat if the standard deviation of the error term increased with age, as it probably would. The size of the error is a function of the slope of the age distribution, and it will therefore increase with age, but it can never have a quantitatively important effect on the age distribution under 70. This error has been discussed at some length because it provides an interesting example of the complex effects of even simple age reporting errors.

In the sections that follow, we review the studies that have shed light on the causes of age distortions in three broad age groups: infancy and childhood (ages 0-14), adolescence and the early childbearing years (15-29), and ages 30 and over. In each case we evaluate the relative importance of content and coverage errors in creating the distortions and attempt to determine the likely characteristics of those whose age is misreported or who are missed by the enumerators.

AGE MISREPORTING FOR INFANTS, YOUNG CHILDREN, AND ADOLESCENTS

The ages of infants and children are probably reported more accurately than the ages of adults. There are two important reasons for this. First, the ages of children are generally reported by parents or other adults who remember the birth. Second, the rapid physiological and psychological changes during childhood make it easier to guess a child's age with reasonable accuracy. However, because accurate reporting of these age groups is so important in estimating recent fertility rates, small errors for these age groups may be more troublesome than larger errors at later ages.

Several recent studies of age misreporting provide exceedingly accurate evidence on reporting errors among children. Two of them, Gibril's study of Gambia (1975) and Pison's study of Senegal (1978, 1979, 1980), are based on matching of individual records from a survey or census with records from long-term medical or demographic studies. A third study by Caldwell (1966) is based on a follow-up survey among 1,000 births recorded in the birth registration area of Ghana. All three provide estimates of the gross errors in the reporting of age.

Table 10 presents the proportion of children whose ages were reported correctly, the proportion exaggerated, and the proportion understated from each of the three studies. Caldwell's data cover only ages 0-8 while Pison's cover ages 3-14. Gibril's data are available only for five-year age groups. All three studies show decreasing accuracy with age; by age 8, only 30 to 40 percent report the correct age. This finding is clearly consistent with the fact that by age 8 physical changes are less rapid than they are under age 5; by age 8, visual examination of a child provides fewer clues to his exact age.

Table 11 shows the mean error in reported ages for Ghana and Senegal. Both studies show a slight bias toward overstating the ages of children up to about age 6. After age 8 the Senegal data show understatement of age; the Gambian data in Table 10 show a clear downward bias in reported age for the 10-14 age group.

Pison noted that at all ages there is a persistent proportion of parents who report their child's age by the number of rainy seasons since the birth (1978:42). Since the 1977 survey was carried out in May, for the children born between May and October the number of rainy seasons since their birth would be one greater than their actual age. Caldwell's explanation for the exaggeration of the ages of young children is similar: if parents tend to round off their child's age, rather than truncating it to the number of completed years, this would lead to an exaggeration of ages. For example, if parents report the age of a child as 4 years if the child is between 3 years 6 months and 4 years 5 months, then about half of the children aged 3 at their last birthday would be reported as 4 years old. His analysis of age misreporting clearly shows that most of the cases of overstatement by 1 year involved persons who were within 6 months of the reported age (Caldwell, 1966:487).

The data from Senegal and Gambia both exhibit larger proportions understating age than overstating age above about age 7, despite the strong persistence of overstatement by 1 year. In Pison's data from Senegal, understatement by more than 1 year is far more common than

TABLE 10 Gross Errors in Reported Ages of Children Aged 0-14, Expressed in Percentages: Ghana, Senegal, and Gambia

	Ghana			Senegal			Gambia		
Real Age	Under-stated	Stated Correctly	Over-stated	Under-stated	Stated Correctly	Over-stated	Under-stated	Stated Correctly	Over-stated
0	--	99	1	--	--	--	--	--	--
1	1	76	23	--	--	--	--	--	--
2	1	66	33	--	--	--	--	--	--
3	9	63	28	7	46	46	--	--	--
4	8	61	31	17	54	29	--	--	--
0-4	--	--	--	--	95	5	--	87	12
5	13	62	25	29	38	33	--	--	--
6	12	57	31	39	43	18	--	--	--
7	27	35	38	45	40	15	--	--	--
8	27	42	31	56	30	14	--	--	--
9	--	--	--	53	31	16	--	--	--
5-9	--	--	--	12	84	4	9	81	10
10	--	--	--	53	36	11	--	--	--
11	--	--	--	58	18	24	--	--	--
12	--	--	--	65	20	15	--	--	--
13	--	--	--	67	15	17	--	--	--
14	--	--	--	59	29	12	--	--	--
10-14	--	--	--	32	64	4	26	66	8

Note: The totals given for ages 0-4 in Senegal are based on the assumption that the ages of all children aged 0, 1, and 2 were reported correctly as 0-4.

Sources: Ghana: Caldwell, 1966:485. Senegal: Pison, 1978:39-40 and 1979:643-646. Gambia: Gibril, 1975:67-68.

TABLE 11 Mean Error in Years in Reported Ages of Children Aged 0-14: Ghana and Senegal

Real Age	Ghana	Senegal
0	0.0	--
1	0.2	--
2	0.4	--
3	0.2	0.4
4	0.3	0.2
5	0.1	0.1
6	0.3	-0.3
7	0.1	-0.5
8	-0.1	-0.8
9	--	-0.7
10	--	-1.2
11	--	-1.2
12	--	-1.5
13	--	-1.5
14	--	-1.5

Note: Positive values indicate a mean exaggeration of age; negative values indicate a mean understatement.

Sources: Ghana: Based on Caldwell, 1966:485. Senegal: From Pison, 1978:39-40 and 1979:643.

overstatement of the same magnitude at ages 6 and above. Caldwell's data for Ghana show a similar pattern at age 8 and some evidence of this phenomenon at age 7.

The Census Evaluation Study of the 1971 census of India produced comparable data on age misreporting among children born during the four years preceding the census. The study matched a sample of births from the Sample Registration System with the census reports on a case-by-case basis. Unfortunately, only partial results from this study have been published. Preliminary information from the study is similar to the results of the other studies. Of the population aged 0-4, 6.1 percent of the males and 4.2 percent of the females were reported as being aged 5-9 (Raghavachari and Natarajan, 1974:5), a result quite consistent with the findings from Senegal given in Table 10.

Table 12 presents the multiplicative adjustment factors needed to adjust the Indian population aged 0, 1, and 2 for net reporting errors. These figures show that the net impact of age misreporting on the infant population is

TABLE 12 Adjustment Factors for Net Age Misreporting for Infants: Evaluation Study, 1971 Census of India

Age in Census	Males	Females
0	1.04	1.01
1	1.35	1.33
2	0.87	0.90

Source: Raghavachari and Natarajan, 1974:4.

slight, whereas the size of the populations aged 1 and 2 is seriously distorted by misreporting. Although the data cover only these three ages, they are consistent with a large amount of age exaggeration among those aged 1. There does not, however, seem to be similar exaggeration among those aged 2.

Table 13 presents data from 19 African censuses which can be compared with the studies by Gibril, Caldwell, and Pison. The table shows the ratio of the population reported at age x to the population reported at age x + 1. In almost all the countries the data show clear evidence of preference for even-numbered ages above age 5. Neither Gibril, Caldwell, nor Pison discusses this kind of digit preference.

Table 14 presents a simulation of age misreporting based on Pison's matrix of age reporting. The simulation starts with a stable population with a growth rate of 2 percent and Coale and Demeny's "North" model life table level 10, and applies the pattern of misreporting indicated by Pison's Senegal data. The results show a clear preference for ages 4, 6, 7, and 10. The pattern of misreporting indicated by the simulation is not exactly the same as the pattern implied by the data in Table 13 from the 1961 census of Senegal. Both show the same preference for age 7; however, in the Senegal census the preference for 7 seems to replace the usual preference for age 6, whereas in Pison's study it replaces the usual preference for age 8. In any case it seems clear that in Senegal there is a preference for even-numbered ages and for age 7.

Caldwell's data (1966:479) provide some evidence of preference for even digits but not enough to explain the 25 percent surplus of persons aged 6 and 8 over those aged 7 and 9 found in the 1960 census of Ghana.

It is quite possible that the careful training of interviewers used for this study or the need to depend on urban populations reduced the amount of digit preference to below the level found in the census.

Preference for ages 8, 10, and 12 is common in data from other parts of the world. A survey of 4 censuses from North Africa, 6 from South America, and 15 from Asia demonstrates that preference for even-numbered ages is very strong almost everywhere. This preference is also found in the World Fertility Surveys in Nepal, Sri Lanka, and Colombia, and a preference for ages 10 and 12 appears in the WFS surveys in Fiji and Mexico.

A second feature of the African census data reviewed in Table 13 is the wide diversity in the ratio of the population aged 0 to the population aged 1. This differs from Caldwell's finding that "extraordinary accuracy characterizes the group under 1 year of age" (1966:485). The range of ratios in Table 13 (from 0.33 to 1.48) suggests that countries vary widely in the degree of underreporting of the population aged 0 and in the degree of accuracy of age reporting among children aged 0 and 1. These ratios can also be affected by annual fluctuations in birth rates and infant mortality rates. In addition, different instructions to the census takers, different emphases in training, and the design of the census questionnaire all affect the reporting and reported ages of children under age 2. It is unlikely that such a wide range could be explained by any one phenomenon.

It is interesting to note that even in the World Fertility Surveys there is great variation in the ratios of the population aged 0 to the population aged 1 and of the population aged 1 to the population aged 2 (Dominican Republic, 1976; Fiji, 1976; Colombia, 1977; Nepal, 1977; Indonesia, 1978; Mexico, 1978; Sri Lanka, 1978). For example, the ratios derived from the survey in Nepal were both greater than one (1.11 and 1.07, respectively), while in Mexico they were both less than one (0.92 and 0.95), and in Fiji they were mixed (0.93 and 1.00).

In summary, it appears that single-year age distributions are frequently distorted by digit preference over age 5, by decreasing accuracy at the older ages of childhood, and possibly by increasing understatement of age. In addition, the population aged 0 is distorted by a variety of factors that make generalizations impossible.

Evidence on the reasons for some of these errors is derived from Scott and Sabagh's study on the value of historical calendars. In their discussion of the various

TABLE 13 Ratio of the Reported Population Aged x to the Reported Population Aged x + 1, for Ages 0-13: 19 African Censuses

Country	Year	Age x = 0 x + 1 = 1	1 2	2 3	3 4	4 5	5 6	6 7	7 8	8 9	9 10	10 11	11 12	12 13	13 14
Botswana	1964	0.56	0.91	0.97	1.00	0.95	1.09	1.00	1.03	1.02	1.01	1.63	0.62	1.55	0.91
Ghana	1960	1.31	0.82	0.90	1.11	1.12	0.94	1.27	1.00	1.25	0.89	1.68	0.66	1.29	1.14
Kenya	1962	1.09	0.62	1.11	0.96	1.25	0.88	1.30	0.78	1.54	0.67	2.26	0.46	1.82	1.24
	1969	0.89	0.89	1.11	0.99	1.09	0.97	1.20	0.90	1.27	0.86	1.54	0.69	1.36	1.09
Lesotho	1966	0.89	1.07	0.91	1.03	0.92	1.04	1.11	0.93	1.08	0.86	1.38	0.71	1.17	0.98
Liberia	1962	1.48	0.55	0.88	1.08	1.11	1.05	1.28	0.91	1.25	0.92	2.17	0.53	1.58	1.15
Mauritius	1952	0.99	0.93	1.09	1.10	1.04	1.19	0.95	1.01	1.30	0.97	1.11	0.87	1.15	1.06
	1962	1.11	0.94	1.01	0.99	1.01	1.04	1.04	1.05	0.96	1.02	0.99	1.03	1.20	1.02
Nigeria	1963	0.80	0.99	0.89	1.09	1.07	1.14	0.89	1.27	0.85	0.96	2.05	0.59	1.58	0.90
Senegal	1961	1.29	0.82	0.91	1.03	1.07	1.09	0.92	1.22	1.30	1.11	1.12	1.04	1.06	1.19

Southern Rhodesia ("African" population)	1969	0.33	1.16	1.09	1.02	0.91	1.12	0.96	1.21	0.78	1.21	1.03	1.17	0.93	0.79
South West Africa	1946	0.84	0.96	0.79	0.99	1.02	0.97	1.13	0.93	1.23	0.83	1.52	0.75	1.43	1.03
Swaziland	1966	1.20	0.85	0.97	1.08	0.96	1.02	1.11	0.94	1.14	0.94	1.34	0.77	1.18	1.07
Tanzania	1967	1.11	0.84	0.87	1.05	1.11	0.98	1.13	1.07	1.16	0.95	1.76	0.64	1.35	1.06
Togo	1958-60	1.41	0.86	0.72	1.32	0.96	0.99	1.16	1.22	1.21	1.19	1.70	0.71	1.42	1.12
Tunisia	1966	0.96	1.00	1.07	1.06	1.09	0.95	1.10	1.03	1.08	0.97	1.10	1.97	1.11	1.05
Uganda	1969	0.69	0.99	1.05	1.04	1.12	0.99	1.22	0.93	1.24	0.88	1.54	0.68	1.32	1.03
Union of South Africa	1946	0.85	0.94	0.99	1.01	1.07	0.92	1.23	0.83	1.30	0.78	1.62	0.63	1.38	1.07
Zambia	1969	1.08	1.05	1.04	1.03	1.02	1.01	1.06	1.14	0.93	1.10	1.14	1.02	1.16	1.03

Source: U.N. Demographic Yearbooks, 1955-73.

TABLE 14 Simulation of Age Misreporting at Ages 3-14, Sexes Combined: Based on Pison's Study in Senegal

	Ages											
Measures	3	4	5	6	7	8	9	10	11	12	13	14
Stable Population[a]	7,324	7,016	6,804	6,598	6,398	6,205	6,017	5,835	5,688	5,544	5,404	5,267
Matrix of Misreporting[b]												
Percent biased:												
up 4 years	--	--	--	2.1	--	--	--	--	--	--	2.2	--
up 3 years	--	--	--	0.0	--	--	1.3	1.6	2.8	6.2	2.2	--
up 2 years	--	3.1	2.6	0.0	1.9	2.0	1.3	0.0	2.8	1.5	4.3	--
up 1 year	46.7	26.2	30.8	15.8	13.2	12.0	13.8	9.4	18.1	7.7	8.7	11.8
0 year	46.7	53.8	38.5	43.2	39.6	30.0	31.3	35.9	18.1	20.0	15.3	29.4
down 1 year	6.7	16.9	25.6	23.2	26.4	28.0	20.0	17.2	20.8	9.2	21.7	17.6
down 2 years	--	--	2.6	12.6	15.1	18.0	21.3	9.4	8.3	29.2	8.7	14.7
down 3 years	--	--	--	3.2	3.8	8.0	8.8	15.6	9.7	6.2	21.7	5.9
down 4 years	--	--	--	--	--	2.0	1.3	7.8	12.5	7.7	0.0	5.9
down 5 years	--	--	--	--	--	--	1.3	3.1	6.9	12.3	15.2	14.7
"Reported" Population		10,214	7,710	9,347	9,075	6,258	5,343	8,232				
Ratio of Reported to Real		1.46	1.13	1.42	1.42	1.01	0.89	1.41				
Population Reported at Age x ÷ Population Reported at Age x + 1		1.32	0.82	1.03	1.45	1.17	0.62					

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[a] The stable or "real" population used is from Coale-Demeny model life tables, "North" level 10, r = 1.02.

[b] From Pison, 1978:39-40 and 1979:643.

estimates of age for children aged 4-13, they report the following (1970:101):

> It is clear that for both males and females there is a noticeable heaping at even ages (6, 8, 10, and 12) in the distribution based on the eye estimate. On the other hand, the distribution based on the calendar estimate is more regular for ages 8-13. The marked heapings at age 7 for both sexes may have been the result of a more frequent use of an important event in the recent history of Morocco (the return of King Mohammed V in 1955). Thus, while the calendar estimate yields a more regular distribution than the eye estimate, it is not free from irregularities generated, in part, by the use of 'popular' events.

From the available studies, it appears that there are several ways in which reporting of ages among children can be improved. First, Scott and Sabagh's study suggests that using an historical calendar with annual events can increase the smoothness of the reported age distribution for children. Although Caldwell and Igun's study (discussed at length in the appendix) suggests that the use of calendars may lead to systematic overstatement of ages, their evidence on this is ambiguous at the youngest ages. A second approach, which might improve reporting of single-year ages among children, would be to try to use local traditional methods of age reporting. For example, if children's ages are frequently based on the number of rainy seasons since their birth (as is apparently the case in Senegal), then collecting data on both the number of winters since the child's birth and the season of the child's birth could improve estimates of "age last birthday." However, the value of such techniques may be limited to certain age groups. Both the use of historical calendars and the use of a question on season of birth could prove useful up to about age 10 or 12, but they probably would be less useful above age 15.

Before proceeding to the older age groups it is important to review some of the data on underenumeration of young children, since both stable population analysis and census survival approaches to studying age misreporting are sensitive to underreporting of children. The comparison of undercounts estimated from post-enumeration surveys in Table 1 showed that in most cases children aged 0-4 were undercounted relative to coverage for the population as a whole. However, because the undercounting of children is not apt to be more than 2 percent relative to the undercount of the rest of the population, the reported proportion aged 0-4 may frequently be off by less than 0.003 percent due to underenumeration (that is, an error of 2 percent in a proportion aged 0-4 that constitutes 17 percent of the total population).

The data presented in Table 1 suggest that census survival estimates of the underenumeration of children aged 0-4 might provide good estimates of the absolute amount of underenumeration, but these estimates probably overestimate the importance of this problem for stable population analysis. The reason for this is that while the population aged 0-4 is usually counted less completely than the rest of the population, those aged 10-14 are generally counted more completely. Therefore a comparison of the population 0-4 at one census with the population 10-14 ten years later probably overstates the underenumeration of young children relative to the total population.

The Census Evaluation Study of the 1971 Census of India produced estimates of the omission rates for children aged 0, 1, and 2. These data, given in Table 15, show an apparent undercount of about 14 percent among infants, 18 percent among those aged 1, and about 8 percent among those aged 2. The slightly higher omission rate for 1-year-olds relative to infants is explained by the fact that all women were specifically asked about births during the previous year (Raghavachari and Natarajan, 1974:5).

TABLE 15 Estimated Omission Rates of Children Aged 0, 1, and 2: Evaluation Study, 1971 Census of India

	Estimated Percent Omitted	
True Age	Males	Females
0	14.5	13.2
1	18.4	17.6
2	9.4	7.1

Source: Based on Raghavachari and Natarajan, 1974:5. Unlike the figures given in the original report of the Evaluation Study, these percentages are the percent of the true population that was not enumerated.

The drop in the omission rate at age 2 suggests that the overall omission rate for the age group 0-4 might be in the range of 10 to 12 percent. Unfortunately, estimates of the undercount for the total population have not been published, so it is not possible to estimate the error in the reported proportion aged 0-4. Since these estimates are based on the matching of birth registration forms with census forms, it would be useful to know the extent of matching problems in the study.

The United States Infant Enumeration Study of 1950 shows one possible reason why the undercount for infants is closely tied to the undercount at other ages. In that study, 82 percent of the infants who were not reported in the census were the children of adults who were also not listed in the census (U.S. Bureau of the Census, 1953). This suggests the hypothesis that the underenumeration of persons aged 15-19 and of children aged 0-4 might be caused by the omission of newly formed small households or families.

AGE DISTRIBUTION DISTORTIONS AND UNDERENUMERATION AT AGES 15-29

Between the ages of 15 and 30 most individuals reach puberty, form their first conjugal union, and have their first children. Along with these changes, individuals often migrate or set up new households. Each of these events marks a change in a person's place in the community, each plays an important role in population dynamics, and each is of primary interest to demographers. The significance of these changes is made even more crucial by the fact that some of our techniques for estimating overall fertility and child mortality rates (especially those developed by Brass) rely heavily on the reported experience of women aged 15-29.

The very factors that make this age group of special interest to demographers are also factors that contribute to the age misreporting and underenumeration of these age groups. In societies in which age is unimportant, ages of young women are frequently estimated by their physical maturity, their union status, or their parity. Likewise, migration and formation of new households are probably responsible for the relatively large amount of underenumeration in this age group. For example, Ware has pointed out that in the Cameroons a young woman who is betrothed but still living with her parents might not be counted in either her parent's home or her future spouse's home since she is in limbo between households (1977:35-37).

Table 16 presents estimates from three studies of age misreporting for persons aged 15-29. Because the studies used different methods of estimating reporting errors, it is difficult to compare the results. Gibril's data are

TABLE 16 Estimates of Age Misreporting for Ages 15-29: Gambia, Indonesia, and Nigeria

Population	"True" Age Group	Sample Size	Reported 5-Year Age Group (percentages)					Average Error (in number of 5-year groups)
			2+ lower	1 lower	Same	1 higher	2+ higher	
Gambia								
Males	15-19	100	1	28	50	15	6	-0.03
	20-24	79	1	10	43	42	4	0.41
	25-29	41	0	10	39	37	15	0.66
Females	15-19	108	2	12	64	12	10	0.16
	20-24	120	3	15	40	37	6	0.31
	25-29	82	1	22	44	27	6	0.17
Indonesia								
Ever-Married Females	15-19	27	--	--	93	7	--	0.07
	20-24	87	--	3	90	7	--	0.04
	25-29	99	--	3	92	3	2	0.04
Nigeria								
Males	15-19	675	--	8	84	8	--	0.00
	20-24	528	--	8	84	8	--	0.00
	25-29	467	--	10	79	10	1	0.02
Females	15-19	549	--	5	85	10	--	0.05
	20-24	570	--	10	81	9	--	-0.01
	25-29	510	--	10	82	18	--	0.09

Sources: Gambia: Based on a comparison of 1971 census records with birth records or with annual surveys, from Gibril (1975:67-68). Indonesia: Based on a comparison of the original interview and a reconciliation interview, from unpublished tabulations from the reliability study of the 1976 Indonesia Fertility Study. Nigeria: Based on a comparison of the conventional census technique with the "model age of cohort" method. The sample sizes correspond to the conventional census. From Caldwell and Igun (1971:297).

undoubtedly the most reliable because they are based on a comparison of the census ages with ages based on birth records for the previous 20 years and on annual surveys carried out for about 20 years. His data show that for both sexes fewer than half of the individuals in this age group were reported in the correct five-year age group. For males aged 15-19 there were fewer ages exaggerated than understated but the upward biases were large enough to make the average error close to zero. However, for males aged 20-29 there was a clear exaggeration of age; in that age group there were about five ages exaggerated for every one that was understated and the average bias was quite large. These results differ from Caldwell and Igun's, which are based on a careful matching of individuals with contemporaries. Their data show that more than 80 percent of the men aged 15-29 were classified in the same age group according to the two estimates of age and there are no apparent tendencies toward exaggeration or understatement.

Gibril's data for females show a clear tendency to exaggerate ages. In each of the five-year age groups more women exaggerated age than understated it and the proportion exaggerating by two groups or more is larger than the proportion understating age by the same amount. The findings from the reinterviewing of a sample of ever-married women from the WFS in Indonesia* shows the same pattern, although the extent of the apparent errors is much smaller than in Gibril's study. The use of reinterviews probably understates the reporting errors, since there may be a tendency to make the same error twice. On the other hand, limiting the survey to ever-married women would tend to exaggerate the amount of overstatement of age by the youngest women if young married women exaggerate their ages more than young unmarried women, which is very likely. Like their data for males, Caldwell and Igun's data for females aged 15-29 show no bias in the age reports and reasonably high degrees of agreement.

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* The data from the Indonesian WFS in Table 16 differ from those published in the report of the study (MacDonald et al., 1978). The report used the results of the reinterview, whereas the figures used here are the result of the reconciliation interviews, which were carried out when the first two interviews differed. Reconciliation was attempted whenever the two reported ages differed by at least two years or when other variables were reported differently. The difficulty of depending on reinterviewing is indicated by the amount of agreement between the original interview and the two later estimates. The percentage disagreement between the reinterview and the original is about twice as large as the differences between the reconciliation age and the original, although the pattern of disagreement is the same no matter which set of "improved" ages is used. For the three age groups--15-19, 20-24, and 25-29--the percentage of agreement between the original and the reinterview are 79, 82, and 75, respectively.

We have already discussed evidence from Haiti and Nepal that shows the ages of women around age 20 are biased according to their marital status, and we have presented information from Nepal and Ghana on the relationship between parity and reported age. These conclusions are verified by Caldwell and Igun's study of age reporting in Nigeria. Although their study did not document large errors in reporting or an overall bias in age reporting, the data in Table 17 clearly indicate that age reporting was affected by parity and marital status. These data show that in Nigeria single women aged 20-24 tend to be reported in a younger age group. It also appears that women aged 15-19, and to a lesser extent those aged 20-24, tend to be reported at older ages if they are married or have at least one child.

Some support for this is provided by Table 18, which presents data from the WFS from Indonesia. Although the numbers are small, it appears that there is a tendency for ever-married women aged 20-24 to be reported in an older age group if they have a surviving child. Gibril's analysis also provides some support for a link between parity and reported age, although his approach to the analysis is somewhat indirect.

Although the causes of underenumeration have not been studied as thoroughly as the causes of age misreporting, the basic mechanisms responsible for excessive underenumeration at ages 15-24 are relatively clear. Most of the young adults who are not enumerated in censuses and surveys are probably (1) residents of one-person households, which are often difficult to identify and enumerate, (2) marginal members of households (for example, servants or nonrelatives), who are not reported as such, or (3) persons whose residence is not well established or who are in the process of moving.

TABLE 17 Percentage of Age Misreporting by Age, Marital Status, and Parity, for Women Aged 15-24: Nigeria 1969

True Age	Reported Age[a]	Marital Status and Parity		
		Single, Parity = 0	Married, Parity = 0 and Single, Parity = 1	Married, Parity = 2+
15-19	Exaggerated	7	16	27
	Same	83	79	70
	Understated	10	5	3
20-24	Exaggerated	5	11	14
	Same	81	81	77
	Understated	15	8	9

[a] Ages exaggerated or understated differed from the true age by at least one five-year age group.

Source: Caldwell and Igun, 1971:301.

TABLE 18 Number of Ever-Married Women by Age, Number of Surviving Children, and Misreporting of Age: Indonesia 1976

Age at Reconciliation	Reported Age[a]	Number of Surviving Children				
		0	1	2	3-5	6+
15-19	Exaggerated	1	1	--	--	--
	Same	16	8	1	--	--
	Understated	--	--	--	--	--
20-24	Exaggerated	1	4	--	1	--
	Same	12	28	26	12	--
	Understated	1	1	1	--	--
25-29	Exaggerated	1	--	1	2	1
	Same	5	14	27	40	5
	Understated	--	1	--	2	0

[a] Ages exaggerated or understated differed from the age at reconciliation by at least one five-year age group.

Source: Unpublished data from the 1976 Indonesian Fertility Survey.

The PES of the 1970 census of Korea provides estimates of the amount of underenumeration by single years of age under age 20. Table 19 presents the estimated undercounts for ages 12-19. It is clear from these data that underenumeration increases substantially during the years when first unions are being formed.

Table 20 presents data from the same study on the underenumeration of ever-married women by age and parity. These data clearly indicate that even among ever-married women childless women are more apt to be missed at every age. At the younger ages the childless women are most apt to be newly married and to be recent additions to an existing household or part of a new household. Among the older women, those without children may be living with relatives or serving as employees. The effects of underenumeration on the reported average parities are insignificant, except at ages 15-19 where the large difference is due to the small number of observations. At other ages the differences between the PES and the census are due to errors in the reporting of parity and age and not to differential coverage by parity.

Table 21 presents estimates of undercounts by relation to the head of household from the PES in Paraguay in 1974 and the PES in Korea in 1970. These data show that about 25 percent of all marginal members of households (that is, employees and nonrelatives) were missed in the censuses. A large proportion of the individuals in these categories are probably young adults. The estimated undercounts for migrants in these surveys are also very high; about 20 percent were missed. Young adults are not only very mobile, they are also most apt to be living alone and therefore are easy to miss in a census.

Although the stable population analysis of the data from Paraguay and Liberia (see Tables 8 and 9) showed that

TABLE 19 Percentage Undercount for Ages 12-19: Korea 1970

	Age					
Sex	12	13	14	15	16-17	18-19
Males	2.4	3.4	4.6	6.1	7.2	10.9
Females	3.3	4.4	4.2	8.3	8.9	8.0

Source: Unpublished data from the 1970 PES of Korea.

TABLE 20 Underenumeration of Ever-Married Women by Age and Parity: Korea, 1960 Census

Parity	PES Total	Omitted from Census	Wrongly Included in Census	% Net Under-count	% Net Undercount by Age			
					<20	20-29	30-39	40-49
0	322	44	28	5.0	2.7	3.5	7.7	3.1
1	656	31	31	0.0	0.0	-0.2	1.5	0.0
2	705	28	24	0.6	0.0	0.7	0.8	2.0
3	679	21	16	0.7	--	0.6	0.6	1.5
4	668	12	17	-0.7	--	-1.2	-0.4	0.0
5	679	21	16	1.3	--	3.1	0.4	0.8
6	606	9	9	0.0	--	-4.3	0.4	0.0
7+	1,454	18	6	0.8	--	64.3	0.6	-0.2
PES Reported Average Parity					0.70	2.16	4.87	6.19
Error in Census Due to Net Enumeration Errors					-0.12[a]	+0.01	+0.01	-0.03
Total Difference Between PES and Census					-0.27	-0.20	-0.44	-0.72

[a] The large understatement of average parity at 15-19 in the census is due to the omission of three women with 3, 4, and 5 births, respectively.

Source: Park, 1966: tables 4-A and 9-A.

TABLE 21 Percentage Estimates of Completeness of Enumeration by Relationship to Household Head and by Migrant Status: Paraguay and Korea

	Completeness of Enumeration (percent)		
		Korea, 1970 PES	
Group	Paraguay 1974 PES	Males	Females
Head of Household	93.6	96.8	94.6
Spouse	94.7	--	96.6
Child	91.8	95.7	95.8
Relative	83.8	89.2	92.0
Employee	72.8	--	--
Criada[a]	84.4	--	--
Other non-relative	75.8	75.6	77.6
Nonmigrants	91.9	95.9	95.8
Migrants	81.4	77.0	77.0
Total	91.1	95.1	95.0

[a] Criadas are young girls who work as servants for room and board. They are frequently relatives or friends of the family.

Sources: Paraguay: Marks and Rumford, 1978:182. Korea: Unpublished data from the 1970 PES.

the adjustments for underenumeration did not improve the fit to the stable population model at ages 15-24, it is important to try to determine the impact of underenumeration on these age groups. The finding from the stable analysis merely suggests that the effect of age misreporting on this age group is larger in magnitude and opposite in direction to the effect of underreporting. In addition, since the individuals who are most apt to be missed are the single and childless, the underenumeration in these age groups might bias estimates of fertility rates and of ages at first union and first birth. It is important that future studies of underenumeration in censuses and surveys provide tabulations of the union status and parity of persons who were missed.

REPORTING ERRORS FOR THOSE OVER AGE 30

While age misreporting under age 30 can be easily understood in terms of changes in physical characteristics and social status, the physical and social changes over age 30 are less dramatic and less frequently associated with specific ages. For example, widowhood and divorce are less useful for age estimation than marital status of persons around age 20. Similarly, the physical signs of aging start to become apparent over a much larger range of ages than the changes associated with puberty. In addition, the low proportion of births recorded in most developing countries more than 30 years ago means that birth certificates and baptismal records are rarely available. The use of birth records for those over age 30 is also complicated by the fact that migrations and poor recordkeeping make it very difficult to locate records of those whose birth was registered.

Two characteristic forms of age misreporting have been noted in many populations. The first is a tendency toward heaping on ages ending in the digits zero and five. Since ages ending with zero appear to be chosen much more frequently as age estimates, this can lead to a surplus of persons reported in the age groups 50-54, 60-64, and 70-74. One example of this phenomenon can be seen in Demeny and Shorter's study of the census of Turkey, which presents correction factors based on census survival ratios between the censuses of 1935 and 1940 and between those of 1955 to 1960 (1968:31). Because Turkey had censuses at five-year intervals, the evidence of heaping at ages ending with a zero is easy to demonstrate.

Further evidence of this kind of heaping comes from Gibril's study in Gambia. Table 22 presents a retabulation of his data, which compares the last digit of the true age with the last digit of the reported age for

TABLE 22 Evidence of Digit Preference Among Persons Aged 40-69: Gambia 1971

	Age Reported in Census			
		Percent in Wrong 5-Year Group (by last digit)		
Last Digit of True Age	Percent in Correct 5-Year Group	0-4	5-9	Total Number of Cases
0-4	32	29	39	221
5-9	20	67	13	181

Source: Based on Gibril, 1975:67-68.

persons aged 40-69. These data show a clear tendency for persons whose true age ends with a digit from five to nine to be switched to an age ending with zero through four. This largely reflects movement to a neighboring age group, but it also includes errors of more than one age group. There is no similar tendency for persons whose age ends with a digit from zero to four to be switched to a neighboring age group; in fact, there are almost as many persons whose age was shifted by two groups (29 percent) as there are those shifted by one group (39 percent). This overall pattern is evident in the data for both sexes and provides clear evidence of the shifting of ages to the five-year groups that include zero.

The relationship noted earlier between misreporting of age and parity among women over 30 in Nepal and Ghana (see Table 5) suggests that future attempts to determine the causes of age heaping in the later years of childbearing should consider the reports of age and parity simultaneously. It is important to note that while the data in the Ghanaian survey could have been distorted by a dependence on third-party reports, in the Nepal survey the fertility histories were collected directly from the women themselves.

In addition to age heaping, there are frequently errors due to exaggeration of the ages of older persons. In U.S. censuses, this is most obvious in the exaggeration of the number of persons reported as being over age 100 (Myers, 1966; Rosenwaike, 1979). It is less obvious but most certainly a problem at younger ages too. The exaggeration of age over age 60 is apparent in several census survival studies of the United States, but the Medicare Record Check of the 1970 census indicated that understatement of age was more common among those aged 65-74. In summarizing the evaluation of the 1960 census, Siegel and Zelnick concluded, "As of now, we do not know the extent, or even the direction, of error in the census count 65 and over" (1966:79). Sorting out the age misreporting errors from the coverage errors is even more difficult. It appears that age exaggeration in the United States is clearly a problem, although the age at which it becomes significant is hard to pinpoint.

In developing countries, Gibril's study once again provides the most reliable evidence of age exaggeration. Table 23 presents a summary of his findings. It is clear from his data that in Gambia age exaggeration among men is a problem as early as ages 30-39, where more than half of the men are reported in an older five-year age group. In

Table 23 Age Misreporting at Ages 30-69: Gambia 1971

		Reported 5-Year Age Group (percentages)					
Sex	True Age Group	2+ lower	1 lower	Same	1 higher	2+ higher	Average Error (in number of 5-year age groups)
Male	30-39	7	12	26	41	13	0.46[a]
	40-49	6	20	27	28	19	0.53
	50-59	11	8	29	19	33	0.92
	60-69	5	10	23	20	43	0.85
Female	30-39	14	25	32	25	5	-0.20
	40-49	17	23	22	23	15	0.39
	50-59	12	18	25	23	23	0.34
	60-69	9	9	18	11	52	1.00

[a] This average excludes two individuals aged 30-34 who were reported as aged 0-4.

Source: Gibril, 1975:67-68.

contrast, there appears to be a very slight tendency for women to understate their age at ages 30-39 and to exaggerate their age at ages 40-59. Over age 60, age exaggeration is clearly a grave problem for both sexes.

5 The Effect of Errors on the Estimation of Fertility and Mortality Rates: Problems and Recommended Solutions

The errors in reported age distributions all have some effect on the estimation of fertility and mortality rates for developing countries. There are three approaches to dealing with these effects. The first is to determine which of the various estimation techniques are most vulnerable to age distribution distortions and to give more weight to estimates from the more robust techniques. A second approach is to try to determine the direction of the bias in the estimates from each technique and to adjust the estimates for that bias. Alternatively, various estimates can be used as maximum or minimum estimates according to their overall bias. A third approach is to estimate the effects of content and coverage errors on the data and to adjust for those biases before applying the estimation procedures. The sections below describe how age distribution distortions affect each of the major estimation techniques and suggest which of these three compensation approaches are most useful in each case.

THE EFFECT OF AGE DISTRIBUTION DISTORTIONS ON STABLE POPULATION ANALYSIS

Of all estimation techniques, stable population analysis has been the most carefully examined for the effects of age distribution distortions. The analysis of age distributions in U.N. Manual IV, designed specifically to improve the use of stable population analysis, led to recommendations on which of the stable estimates are apt to be biased in specific directions and on how to select one stable estimate from among all possible estimates.

The evidence on patterns of age misreporting discussed in the previous section support an alternative approach to the use of stable population estimation of fertility rates. The emerging evidence suggests that it might be possible to develop some standard patterns of age misreporting and relative underenumeration, which could be applied to a variety of countries. For example, the evidence presented in Table 1 suggests that the population over age 35 is generally enumerated more completely than other age groups. These data suggest that it would not be unreasonable to adjust a reported age distribution for a relative overcount of 2 to 3 percent at all ages over 35.

A second example comes from the data on Korea and Paraguay (Table 21), which demonstrate that the degree of underenumeration is closely related to the relationship to the head of household. In particular, both studies showed about a 7 percent relative undercount for relatives other than spouse and child and about a 20 percent undercount for nonrelatives. If this pattern can be substantiated by further studies, it would be reasonable to adjust reported age distributions for the underenumeration rates by relationship to household head. (Naturally, this would also involve adjusting the number of close family members for a relative 1 percent overcount.)

Obviously, such an approach to adjusting recorded age distributions would have to be substantiated through further studies, and if different synthetic approaches yield different estimates, the analyst must decide which adjustment or average of adjustments to accept. It should be noted, however, that all of these adjustments would probably be slight in comparison with the gross distortions that are often observed.

To demonstrate how such an approach would work, we have applied it to the population of males from the 1970 census of Ghana. Several different approaches to adjusting the age distribution were tested. The first approach was to adjust the population over age 35 for an estimated 3 percent relative overcount. This adjusted age distribution was then used to calculate estimates of the crude birth rate (CBR) using Coale and Demeny's

"West" model life table level 13 and the assumption that life expectancy increased from 38 years in 1948 to 48.5 years in 1968 (Gaisie, 1976:13). These estimates can then be compared with similar estimates based on the reported age distribution. The results, presented in Table 24, demonstrate that the adjustment increases the consistency of the estimates slightly and increases the median CBR estimate by about 0.5 births per 1,000 population.

A second approach adjusted the age distribution by assuming that there was a 1 percent relative overcount among close relatives of the head of household (including the heads of households, their spouses, children, and parents), a 7 percent relative undercount of other relatives, and a 10 percent undercount of nonrelatives. This adjustment also increased the consistency of the estimates and increased the estimated CBR slightly.

Since Caldwell's research showed that about 4 percent of the population aged 0-4 in 1960 exaggerated their age in 1960, we can test the effect of an increase in the proportion under age 5. Adding this adjustment to the reported data and to each of the adjusted age distributions leads to a further increase in the estimated CBR and increases the inconsistency among the CBR estimates based on the reported age distribution.

Although more research is required before these kinds of adjustments can be made routinely before using the age distribution to estimate fertility rates, several observations are justified. First, these rather ad hoc adjustments all increase the consistency among the eight CBR estimates. Although the changes are not large, they are significant enough to warrant further tests of this approach. Second, each of the tested adjustments leads to an increase in the median CBR estimate. This finding lends support to Krotki's concern that the use of stable or quasi-stable models will lead to underestimates of the CBR (Krotki, 1969). The most extreme example, that using Caldwell's adjustment and the adjustment for the 3 percent relative overcount over age 35, leads to a median CBR estimate 1.5 points higher than the median estimate based on the reported age distribution. The evidence from this test and the previous tests using data from Paraguay and Liberia (Tables 8 and 9) suggest that stable and quasi-stable estimates of the CBR might frequently be biased downward by about one point per thousand due to age-selective underenumeration.

TABLE 24 Quasi-Stable Population Tests of Adjustments for Age Distribution Distortions: Ghanaian Males, 1970

Part A. Adjustments Applied to Ages 5-40

	Reported Distribution		Adjustment Based on 3% Overcount of Ages 35+		Adjustment Based on Relationship to Head of Household	
Age	C(a)	CBR	C(a)	CBR	C(a)	CBR
5	18.32	46.99	18.44	47.33	18.32	46.99
10	35.46	51.39	35.70	51.84	35.44	51.35
15	47.57	50.40	47.89	50.90	47.61	50.46
20	56.97	48.84	57.35	49.42	57.16	49.14
25	64.16	46.77	64.59	47.37	64.48	47.22
30	70.99	46.04	71.46	46.75	71.34	46.56
35	77.19	45.95	77.71	46.83	77.52	46.50
40	82.41	45.77	82.76	46.44	82.68	46.29
Median CBR:		46.88		47.35		47.11
Mid-Range:		2.80		2.67		2.58

Part B. With the Addition of Caldwell's Adjustment to the Population 0-4

Age 5:	19.05	49.12	19.18	49.56	19.05	49.12
Median CBR:		47.81		48.17		48.40
Mid-Range:		3.08		2.58		2.76

Note: See text for details of assumptions about mortality levels and for details of adjustments. Unlike Tables 8 and 9, this table presents only eight CBR estimates, because the tables for adjusting the CBR estimates for the mortality declines cover only the first eight estimates (United Nations, 1967:120).

To be able to extend this approach, more information is required on the characteristics of individuals who are most apt to be missed by a census and of those whose ages are misreported. It may be that standard adjustments for these errors should be based on marital status, parity, or education rather than relationship to household head. However, it seems that this approach of making minimum adjustments to the age distribution based on standard expectations about the kinds of people who are apt to be missed or reported incorrectly can improve the fertility estimates made from stable population analysis.

AGE MISREPORTING AND THE BRASS "GROWTH BALANCE" TECHNIQUE

Brass has recommended a technique for adjusting reported age-specific death rates for underreporting of deaths by comparing the population over a given age with the death rate for the population over that age (1975:118-123). To test the sensitivity of this technique to age misreporting, Rashad (1978) conducted a simulation of age misreporting. She tested two models: one with the same pattern of misreporting for the population and the deaths, the other with two different patterns. Her simulations show that the CDR estimated from the Brass method can easily be off by 1 or 2 points per thousand in the presence of age misreporting. She also demonstrated that smoothing the age distributions of the total population and the deaths separately before applying the Brass technique tends to increase the error in the estimated CDR. The reason for this is that the technique is itself a smoothing technique. The use of a mechanical smoothing procedure before applying Brass's technique is less efficient than relying simply on the technique alone, because unlike the usual smoothing procedures, the technique is based on a mathematical model of the expected relationship between the distribution of deaths and the distribution of the population.

THE EFFECTS OF AGE DISTRIBUTION ERRORS ON THE BRASS TECHNIQUES FOR ESTIMATING FERTILITY AND CHILD MORTALITY

The Brass procedures for estimating fertility and child mortality were designed to capitalize on the fact that the fertility experience of young women and the mortality experience of their children are good indicators of recent fertility and mortality. However, by relying heavily on the parity, number of deceased children, and recent fertility reported by young women, the Brass procedures become very vulnerable to the gross errors in age reporting among women aged 15-29. If age reporting errors were random, it is unlikely that they would cause biases in the estimates of fertility and child mortality; however, as we have seen in earlier sections, they are closely linked to parity and union status. Of the three variables needed for the Brass procedures, parity is probably the one most closely related to age reporting and recent fertility is probably the least. Whether biases are introduced by age misreporting related to child survival rates is not clear.

The distributions of average parity by single years of age for Nepal and the Ashanti region of Ghana (Table 5) show clearly the effect of age estimates based on parity. In using Brass's approach to estimating fertility, the question is: To what extent are the estimates of P2 and P3 (the average parities at ages 20-24 and 25-29) biased by this misreporting? For the Brass estimation of child mortality, the questions are: How does this misreporting bias the estimate of the ratio of P1 to P2 (the ratio of parity at 15-19 to parity at 20-24) and the ratio of P2 to P3; how does age misreporting affect the reported proportions of children dead by ages of mothers; and how do these effects interact?

One way to look for evidence that biases in fertility and mortality estimates are due to age misreporting is to produce estimates for a population using several different classifications of age. If the data are reported properly, then the fertility and mortality estimates should be the same whether we use the age groups 15-19, 20-24, and 25-29 or groups 18-22, 23-27, and 28-32. We can use multipliers based on Trussell's equations for the procedure (Hill et al., 1981) as long as the five-year age groupings used for P1, P2, and P3 are the same as those used for the proportions deceased. If the estimates from these different age groupings are significantly different, this would be evidence that the distortions in the age distribution are related to parity in ways that would bias the estimates of the demographic rates.

Although the procedure outlined above can provide evidence of misreporting biases, close agreement among the various estimates would not prove a lack of bias. For example, if the women 15-19 who are wrongly classified as 20-24 had lower parity than the average for women 20-24 and higher parity than the average for women 15-19, both P1 and P2 would be biased downward. If the same kind of mechanism operated between ages 20-24 and 25-29, then both P2 and P3 would lead to estimates of fertility that would be biased downward. If the exaggeration of age were smooth (that is, if similar proportions were shifted from 19 to 20 and from 20 to 21, etc.), then all age groupings would lead to estimates with similar biases. Fortunately, it appears from Table 5 that the age exaggeration is not smooth and leads to a surplus of women at ages 20 and 25.

To look for evidence of biases due to misreporting, we have produced four sets of estimates of fertility and child mortality using different age groupings of the data from the Ashanti region of Ghana. Using the four age groupings and both P2/F2 and P3/F3, we derive eight estimates of the total fertility rate. These estimates, presented in Table 25, range from 7.61 to 8.06, indicating that age misreporting is distorting the Brass fertility estimates, however differences of this size (roughly 6 percent in this case) are not critical for most policy-oriented uses of fertility estimates. It is important to note that the difference between the P2/F2 and P3/F3 estimates for each of the four age groupings is small, ranging from 0.15 to 0.19, although the relationship between the P2/F2 and P3/F3 estimates changes. It is also interesting to note that the estimates based on traditional age groups are on average similar to those based on 18-22, 23-27, and 28-32. Table 25 also presents estimates of life expectancy at birth based on Brass estimates of q(1), q(2), q(3), and q(5) using each of four different age groupings. The differences in the e_o estimates among the four age groupings are smaller than those among the four q(x) values.

The results of these tests and similar tests by Hill et al. (1980) suggest that age heaping may not be a major problem in using the Brass methods for estimating fertility and child mortality. This conclusion is

TABLE 25 Estimates of Fertility and Child Mortality Derived from Different Age Groupings: Ashanti Region, Ghana 1971

		Age Range for P1			
Parameter	Basis of Estimate	15-19	16-20	17-21	18-22
Total Fertility Rate	P2/F2	7.78	7.91	7.70	7.61
	P3/F3	7.62	8.06	7.86	7.80
Life Expectancy at Birth (e_0)	q(1)	57.10	55.86	55.07	55.26
	q(2)	53.49	53.49	53.49	52.91
	q(3)	51.58	50.47	50.59	50.47
	q(5)	49.63	49.21	49.21	48.98

Source: Unpublished data from the Ghana 1971 Supplemental Enquiry.

supported by recent evidence (Ewbank, 1980) that a large part of the inconsistencies between Brass-type estimates of survival to ages 1, 2, 3, 5, and 10 probably are due to mortality differences by parity and to recent fluctuations in mortality rather than to age misreporting.

Nevertheless, comparing estimates based on different age groupings may prove to be useful in several ways. First, it may be a relatively simple way of determining a reasonable range of estimates. It is too early to speculate on how this range is related to the actual value, but simulations may provide a way to interpret the differences among the estimates. Secondly, the different estimates can be used as a way to test whether the kinds of misreporting built into simulations are a reasonable approximation of reality. Unless the simulation can produce single-year distributions similar to the reported values, the results of the simulation may not be useful.

Third, it may be that simulation studies will be able to determine which of the age groupings provides the least biased estimates. If the age misreporting is due mostly to ages being exaggerated from 15-19 up to 20, from 20-24 up to 25, and from 25-29 up to 30, then the 16-20 grouping would yield the most reliable estimates. It is important to note that this grouping also yields the highest estimates of fertility. This is probably due to the fact that the 15- to 19-year-old women of relatively high parity tend to be reported as aged 20. If these women also lower the average for the 20-24 age group, and if similar effects occur at ages 25 and 30, then the 16-20 grouping could provide the most accurate estimates.

Two researchers, van de Walle (1968) and Santow (1977), have used simple simulations to examine the impact of age misreporting on Brass estimation procedures. Van de Walle tested the effects of various simple patterns of age misreporting on the Brass method of estimating fertility from data on reported average parity and reported recent births. By simulating the effect of several relationships between reported age, parity, and recent fertility, he examined the possible biases in ratios of parity (P_i for age group i) to cumulated recent fertility (F_i) for different age groups. Although his efforts were hampered by a lack of information on the relationship between age misreporting, parity, and recent fertility, van de Walle's approach, which was also tested in Pakistan by Karim and Iqbal (1975), provides a valuable model for future simulation research on the impact of age misreporting.

Santow's study added age misstatement to a micro-simulation model of fertility to analyze the impact on the Brass estimates of child mortality. One of the simulations involved shifting upward the age of half the women whose parity was above average for their age group. This was done in all three five-year groups: 15-19, 20-24, and 25-29. A second simulation increased the age of every woman with above-average parity.

Table 26 presents Santow's estimates of the female life expectancies at birth (e_o), which correspond in Coale and Demeny's "North" model life tables to the q(x) values from each simulation. For the moderate level of mortality, the e_o values estimated from simulations with no misreporting and those estimated from simulations with half of the ages shifted differ on average by about one year. For the higher-level mortality simulations, the differences are about the same. The mixed simulation for the medium level of mortality involved shifting all of the above-average parity women aged 15-19 and half of those aged 20-24. This simulation is interesting because it shows a q(1) estimate that is biased in the opposite direction from the q(2) and q(3) estimates.

The pattern of age misreporting that Santow used in his simulations is very simple. One possibility not examined by Santow is that age misreporting might be

TABLE 26 Simulations of the Effect of Age Misreporting on Brass Child Mortality Estimates

	Female Life Expectancy at Birth (e_0)			
		With Age Misreporting		
Parameter	With No Age Misreporting	Half Shift	Full Shift	Mixed
Moderate Mortality				
q(1)	61.4	63.5	66.2	65.9
q(2)	60.6	61.4	64.2	60.3
q(3)	60.3	60.3	60.7	59.4
High Mortality				
q(1)	45.3	44.1	50.4	--
q(2)	38.2	40.9	46.6	--
q(3)	37.3	38.8	39.5	--

Source: Santow, 1977. Santow's q(x) values have been used to find estimates of overall mortality using the Coale-Demeny "North" model life tables. See text for explanation of shifts.

related not only to a woman's parity but also to the number of her children who are deceased. There are two ways in which this might occur. First, if a woman's first and only child is now deceased and she is not in a union, there is a good chance that that child might not be recorded. Therefore, women aged 20-24 whose only child is dead might be classified as aged 15-19. The primary result of this would be to bias upward the proportion surviving among the children of women aged 20-24.

A second case that should be considered is that of a woman aged 19 whose firstborn died. In a population with an early age at first birth, it might not be unusual to find a woman aged 15-19 with one child. However, if the birth intervals are long (possibly because of prolonged breast-feeding), then it might be very unusual to find a woman aged 15-19 with more than one child. A woman whose firstborn dies at a very early age will not be breast-feeding and thus is likely to have a second child quickly. Therefore, of those women aged 15-19 who have a first birth, those whose child dies will be more likely to have a second birth before age 20. Since those aged 15-19 with two births are more apt to have their age exaggerated, it follows that women whose firstborn dies may also be more apt to have their age exaggerated. This would lead to an understatement of mortality among the children of women aged 15-19 and to an exaggeration of mortality for the children of women aged 20-24. It would also affect the reported values of P1 and P2.

One difficulty with Santow's simulations is that each simulation was run only once and the results reflect the effects of both misreporting and of random elements from the simulation. To overcome this, Santow has run significance tests on the differences. Of the figures presented in Table 26, only the differences between the no-shift and full-shift models for the high mortality case are significant.

In conclusion, the Santow simulations produced biases similar to the differences found in the Ashanti data using the different age groupings. The simulations both suggest that the biases due to age misreporting may be no larger than those due to other problems with the Brass method. However, further simulation work is needed to fully demonstrate the nature of the biases introduced by such data errors.

THE EFFECT OF AGE MISREPORTING ON THE BRASS PARENTAL SURVIVAL TECHNIQUE FOR ESTIMATING MORTALITY

In the discussion of age misreporting for the population over age 30, it was noted that exaggeration of age is clearly a problem at the oldest ages, but it is not clear at what age exaggeration becomes a major problem. Gibril's data show that males in Gambia tend to have their age exaggerated by an average of one half of a five-year age group at ages 30-49 and by a full five-year age group at ages over 50. Gambian females apparently understate their age slightly until age 40; at ages 40-59 their ages are exaggerated by about one third of a five-year age group and by a full age group over age 60. These distortions at high ages lead to biases in the estimation of adult mortality. In countries like Gambia, therefore, for these age groups more reliable estimates of adult mortality may be derived from reports of parental survival, using Brass's parental survival technique.

Table 27 presents the results of a simple simulation to test the sensitivity of this technique to age exaggeration among those aged 30 and over. The simulation assumes that the true mortality of a population of males is given by Brass's African Standard life table. However, because of age misreporting, what we think is the proportion surviving from age 30 to age 60 actually

TABLE 27 Simulation of the Sensitivity of the Brass Parental Survival Method to Age Misreporting

True Age x	Probability of Surviving from Age 30 to Age x[a] $l(x)/l(30)$	Reported Age[b] $x + 2.5$	Logit Fit to Standard with $l(x)/l(30)$ and $l(2)$[c]		
			α	β	$\hat{e}_0 - e_0^s$
57.5	0.6552	60.0	0.071	0.912	2.25
62.5	0.5498	65.0	0.074	0.909	2.33
67.5	0.4284	70.0	0.076	0.906	2.38
72.5	0.2973	75.0	0.085	0.894	2.70

[a] From Brass's African Standard life table.

[b] Because of the assumed pattern of age exaggeration by respondents, survey results will lead us to believe that x is 2.5 years greater than is actually the case.

[c] Fit to Brass's African Standard using actual $l(2)$ from the Brass Standard. If the exaggeration of x is unimportant, then α will be close to zero, β will be close to 1.0, and the estimated life expectancy ($\hat{e}_0$) will be close to the value for the standard (e_0^s).

represents the proportion surviving from age 30 to age 57.5. This is equivalent to an average exaggeration of age by 2.5 years among men who are actually aged 27.5. (In this simulation, it was assumed that we know the correct value of l(2). Life expectancies were then calculated from the values of l(x)/l(30) and l(2) by finding the values of α and β for the logit life table that are consistent with the data, using a procedure similar to that described by Brass (1975:105). These parameters were then used to produce an estimated life table. (For reference, see "logit" in the glossary; for a more complete description of the procedure, see Hill et al., 1981.)

The results of the simulation demonstrate that exaggeration of age has a significant effect on the estimated life expectancy. Age exaggeration of approximately 2.5 years will bias the estimate of life expectancy upward by approximately the same amount. This result is what would be expected. Since the ages of the respondents are exaggerated, we are led to believe that their parents have survived to an older age than is really the case, therefore, the procedure underestimates mortality. The exact amount of the bias will depend on the shape of the life table survivorship curve over the ages in question. This simulation provides only a preliminary estimate of the effect of age misreporting on the parental survival technique. It may be that the actual effect is quite different from these estimates, especially if age exaggeration is more (or less) common among those whose parents are deceased than it is for the population as a whole.

Age misreporting has another less obvious though potentially important impact on the estimation of mortality. Because age misreporting is a problem at the oldest ages in almost all populations, it is very difficult to establish the shape of the survivorship curve at the oldest ages. This was made clear in a U.S. study that matched death certificates with census records on a case-by-case basis (U.S. Public Health Service, 1968). The study demonstrated that at the oldest ages the ages reported on the death certificate and the census form were frequently different. For U.S. nonwhites, mortality rates calculated using the age reported in the census were significantly lower than those calculated using the death certificate age for the numerator. This study demonstrates that determining the age pattern of mortality at the oldest ages is difficult even when the registration is essentially complete.

The standard pattern of mortality that we use for the logit model must be based on reliable mortality data for populations with a mortality pattern broadly similar to the population being studied. In practice, however, model tables for high levels of mortality are likely to be distorted by age misreporting, too. Thus, the fit of the data to the model may be misleadingly satisfactory. In short, the Brass parental survival method may be potentially biased not only by age misreporting in the population under study, but also by the effects of age misreporting on the standard life table used to smooth the survivorship estimates obtained.

6 Conclusions and Recommendations for Future Research

Since the publication of Manual IV (United Nations, 1967) and The Demography of Tropical Africa (Brass et al., 1968), numerous studies have provided insights into the patterns of age misreporting and age-selective underenumeration. Although these studies do not drastically alter the conclusions reached in previous surveys, they do clarify the sources and patterns of misreporting and help quantify the magnitude of various types of errors; in particular, they have helped clarify the relative importance of content and coverage errors.

The first of this report's three purposes was to review the available studies on the sources, patterns, and consequences of age misreporting and age-selective underenumeration. Its second aim was to suggest ways in which information on reporting errors can be used simultaneously to adjust existing data and to study the relative importance of different types of errors. Two of these suggestions are (1) to combine PES data on errors with stable or quasi-stable population analysis and (2) to compare Santow's simulations of the impact of misreporting on the Brass method of estimating child mortality with tests conducted by using different five-year age groupings on the results of the Brass method.

The third purpose of this paper is to recommend ways of improving how we deal with reported age distributions and to suggest directions for future research in this area. These recommendations and conclusions are as follows:

1. One crucial step toward improving the quality of reported age distributions is to determine as well as possible what type of questions are most likely to yield reliable age reports in the particular population being surveyed. The questions posed to the respondents should be grounded in an awareness of features of the culture that are likely to affect their knowledge of and willingness to report their ages. Pretesting questionnaires on a sample of the population is one essential way to check the efficacy of different questions about age, and consultation with researchers knowledgeable about the anthropology of the population is useful.

2. The effect of interviewers on age reporting should not be underestimated. Evidence suggests that the quality of age reporting depends strongly on the educational level of the interviewers as well as on their previous experience and the training provided them. Higher investments in the recruitment and careful training of interviewers are likely to produce greater consistency and accuracy in age reporting.

3. Whenever possible, questionnaires should be designed to eliminate interviewers' performing arithmetic in the field. The chance that additional error will be introduced is greater when intermediate calculations are performed between collecting information directly from respondents and subjecting it to analysis.

4. Efforts to improve age reporting in surveys through the use of local calendars of historical events are probably a waste of time and money. The one exception to this is the use of calendars for estimating the ages of children under age 10. The evidence, which is reviewed in the appendix, suggests that these calendars are rarely used properly in large surveys and censuses and that when they are used they are apt to lead to biased estimates of ages for adults. In large surveys, efforts to improve age reporting probably should be limited to requesting birth certificates and other documents that help in estimating ages. Although this may prove useful in only a small proportion of the population, there is evidence that such documents are

underutilized in areas where enumerators do not expect people to have them. Similarly, some of the larger errors might be reduced by efforts to decrease the amount of proxy reporting. It would also be helpful to have more complete tests of the usefulness of estimating age from such data as duration of marriage and age of oldest child, as in Agarwala's 1960 analysis of the Mysore Survey.

5. In censuses, more attention should be paid to ensuring a complete count and to estimating the completeness of the count. For example, simply reminding respondents that servants and employees living in the household are to be reported might improve the accuracy of the reported proportion aged 15-19 more than using special techniques for age reporting. Although in many societies age misreporting is probably more common and more of a problem than underenumeration, in many situations the latter is more easily measured. In this regard, we agree with Marks's conclusion that post-enumeration surveys should be designed primarily to measure coverage errors and not content errors.

6. Published analyses of studies of age misreporting and age-selective underenumeration rarely provide the kinds of information needed to understand the sources of the errors and their potential importance in other populations. For example, none of the PES studies reviewed here included any tabulations that can be used to understand the relationship between age misreporting and parity of young women. There were also no tabulations of underenumeration by marital status and only one tabulation of underenumeration by parity. If we are to develop better models of misreporting and underenumeration and methods for adjusting for their effects, we need better information about what kinds of individuals are missed or misreported. Tabulations similar to Tables 17, 18, 20, and 21 could be derived from data tapes of existing studies. These issues have probably been neglected because most researchers are interested primarily in adjusting the data from the particular survey on which they are working. In the process, more general questions, which might prove applicable to other populations, frequently have been overlooked.

7. Stable population analysis and census survival approaches to studying age distribution distortions have been neglected recently. The 1970 round of censuses opened up new research possibilities in a number of countries that now have two comparable censuses for the first time. A comparison of the deviations from stability or the patterns of census survival rates from various countries could be used to examine such questions as: (1) What is the effect of various questionnaire designs on the quality of reported age distributions? and (2) What is the relationship between the apparent shortage of females reported at ages 15-19 and the ages at first marriage and first birth? Although there are numerous problems with these techniques, they have two important advantages: first, they allow new information to be obtained from existing data; and second, they can be applied to a large number of populations and therefore can provide information about the variety in patterns of distortions in age distributions.

8. There have been far too few comparisons of the results of studies of age misreporting and coverage errors and the results of studies that use stable population and census survival approaches. Comparisons of this type using U.S. data have raised serious questions about the usefulness of the results of studies of age misreporting and coverage errors. The comparisons in Tables 7, 8, 9, and 24 and the comparison of Gibril, Pison, and Caldwell's estimates of age misreporting among children (Table 10) with census data from 19 African censuses (Table 13) demonstrate that extreme caution is needed before the results of these studies can be generalized to other populations or even used to adjust census data for the same population. In addition, if the survey results do prove to be reliable and more widely applicable, combining the results with stable population and census survival techniques will provide a clearer picture of the errors and deviations from stability that remain in the data after the one adjustment has been made.

9. The studies by Gibril, Pison, Caldwell, and Murray suggest that studies with moderate sample size that match age reports and birth certificates or baptismal records can produce valuable results even in countries where such records are rare. For example, although Caldwell's study was based on data only from towns included in the birth registration area of Ghana, the results seem to be useful

in understanding age misreporting for all of Ghana. The need for further studies of this sort is clear when we consider that the studies by Gibril, Pison, and Caldwell are the best of their type and provide our clearest evidence of patterns of age misreporting, yet all three are studies of West African populations. The almost complete lack of such studies in South America and Asia threatens us with the possibility that our models of age misreporting may be overly culture-bound. Murray's study of Haiti, which is unpublished, suggests the possibility that other anthropologists may have similar unpublished data that could help answer questions about the nature of reporting errors in other parts of the world. Comparable data might be available from historical studies that include multiple sources of information on the same individual.

10. The simulations by Rashad, van de Walle, and Santow of the effect of age misreporting on the Brass techniques and the tests displayed in Tables 25 and 27 are preliminary steps toward the use of simulation to elucidate the biases in existing estimates of mortality and fertility. The preceding discussions suggest three useful aims for future simulation studies: (1) they should provide simulations of single-year distributions that can be compared to data similar to those given in Table 5 to test the realism of the simulation; (2) they should test the robustness of estimates based on alternative age groupings, as demonstrated in Table 25; and (3) they should compare the effects of alternative patterns of reporting, especially patterns that indicate a relationship between age misreporting and the underenumeration of such characteristics as survival of children and survival of parents.

SUMMARY

Although age misreporting and selective underenumeration will continue to plague demographic studies, the recent evidence suggests that we can do a much better job of adjusting data for misreporting errors and of developing techniques for estimating fertility and mortality that are less sensitive to age reporting errors. Unfortunately, all too frequently we settle for estimates that we realize are affected in some unknown way by misreporting and underenumeration. Although age misreporting and age-selective underreporting are only two sources of error in our estimates, the preceding discussion makes it clear that they are not trivial sources of error and that there are ways of reducing such errors.

Age misreporting and selective underenumeration frequently are viewed as important but uninteresting problems. The fine research carried out by a number of scholars in various populations clearly demonstrates that with carefully planned field work and thoughtful analysis, combined with comparison of results from different sources and techniques, we can expect to produce improved ways of dealing with one of demography's most frustrating problems.

Appendix

The Usefulness of Historical Calendars

> . . . and we, in our researches, must either stop at the conditional and apparent beginnings, confusing them with the real beginning, in the same way that Joseph confused the man from Ur on the one hand with his father, and on the other hand with Joseph's own great-grandfather, or else we must keep on being lured from one time coulisse to the next, backwards and backwards into the immeasurable.
>
> -- Thomas Mann,
> Joseph and His Brothers

The historical calendar of local events has frequently been used as a technique for estimating ages in populations where knowledge of ages and birth dates is rare. Preparing useful calendars is time-consuming and their use lengthens the interviewing process, so it is important to determine whether and when these extra costs are justifiable in terms of the expected improvement in age reporting.

Several major problems exist with the use of historical calendars. The first is one that greatly limits the usefulness of calendars in large surveys: the difficulty of producing lists of events that are known to the respondents in each local area. In many countries a calendar of national events is not very useful for estimating ages. People may not be sufficiently aware of national events to remember even the most important ones (Gibril, 1979:36; Seltzer, 1973:16). This is probably especially true in relatively new nations and in countries in which large parts of the population are illiterate and do not have access to radios. Secondly, even when people remember events of national significance, those events may be so far removed from their daily lives that they are unable to relate them chronologically to personal events such as births or marriages.

While it is possible to produce useful calendars, it is time-consuming and expensive (Seltzer, 1973:16). In fact, unless the calendars are created under careful supervision and unless plenty of time is allowed for the process, they may simply not be constructed. For example, in both the 1960 census of Ghana and the 1967 census of Tanzania a short calendar of national events was given to each enumerator. In both cases this short calendar was to be supplemented by a list of local events constructed by the enumerators. There is no evidence as to how many of these local calendars were ever constructed (Gil et al., 1971:xxxvi; United Republic of Tanzania, 1971:87). In the 1973 National Demographic Survey of Tanzania, local calendars were to be constructed in each of the 72 rural sample areas before the interviewing began. Because of a shortage of time, calendars were produced for only about half of the clusters, and some of these included only a few events in addition to the national calendar (Ewbank and Hogan, n.d.).

The difficulties involved in producing a proper calendar are made clear by Scott and Sabagh's description of the kind of calendar that is necessary for accurate age reporting. They maintain that a calendar should contain "events covering every, or almost every, year of the past century or so" and that monthly events are required for the most recent two years (1970:94-95). This level of detail is particularly important for the 15 years prior to the survey. Unless the calendar includes at least one event for each of the prior 15 years, it is unlikely to be an improvement over guesses based on appearances.

A second problem with using calendars is that they are very difficult to use properly and require a great deal of patience and persistence. Gibril reports that interviewers in Gambia tended to avoid using the calendars because of the complexities and because some of the respondents resisted the calendar approach (1979:36). For example, some respondents refused to answer questions about events after having already stated an estimated age; some appeared to resent this probing because it implied that the answer they had already given might be wrong. In Ghana there was apparently the same problem in the 1960 census. Interviewers were trained to use several methods of age estimation with the suggested order of preference being: birth or baptismal certificates, historical events, local events, and facial appearance. Experience in the pre-census survey showed that "a large percentage of the enumerators (subsequently, main census field supervisors) even in the southern portion of Ghana resorted to the last method"--that is, to estimating age from appearance (Ghana, 1964:388).

Scott and Sabagh studied the use of local calendars in rural areas during the 1961-1962 Multi-Purpose Survey in Morocco. They too discovered that the calendar was not always used. During the first round of the survey they found that "age was often being estimated at sight, or by report, and the columns concerning the calendar were being completed afterwards to fit this estimate" (1970:95). In the second round, when the interview procedure was revised and more supervision was provided, they found that the calendars were used to estimate the ages of 87 percent of the men and 75 percent of the women. The calendar was used least in the case of men aged 15-29 (70 percent) and women aged 15 and over (about 60 percent). They attribute these low percentages to the fact that calendars cannot really be used to estimate the ages of adults who are not seen by the enumerator. In Morocco, male interviewers are apparently not able to interview a large proportion of the adult women, and many men aged 15-29 may be temporarily absent (1970:96).

As was stated previously, in the 1973 National Demographic Survey of Tanzania there was an attempt to produce a local calendar for each of the 70 rural clusters. However, because of time constraints the quality of the local calendars varied greatly. Analysis of the data reporting using the U.N. index of misreporting (Ewbank and Hogan, n.d.:30-31) demonstrated that the most important factor determining the smoothness of the age distributions was the education level of the interviewers. The interviewer team with the lowest level of education was responsible for the interviewing in four of the six regions with the highest U.N. scores for age misreporting (out of a total of 18 regions). However, even the best teams produced age distributions that were heavily affected by misreporting. Moreover, there was no correlation between the number of events listed in the local calendar and the age reporting index for that area. This suggests that in large surveys the difficulty of producing local calendars and training and supervising interviewers might well reduce the impact of the calendars to the point where they are not cost effective.

There is evidence to suggest that even when local calendars are carefully produced and used they may not produce particularly good estimates of age. For example, Gibril notes that in Gambia there was often confusion between two events in the calendars, which complicated their use. He specifically mentions confusion between the first and second world wars, between the time of independence and the gaining of republican status, and between the date of the coming to Gambia of a river boat as opposed to the arrival of a ferry (1979:33). Scott and Sabagh also discuss this problem and describe a case in which confusion between two similar events in the calendar led to one woman's age being misreported by 15 years even though she was educated and clearly knew her exact age (1970:104). Gibril points out that even when an event is remembered properly, there is still the problem of establishing the person's age at the time of the remembered event (1979:37).

More serious evidence of poor results from a carefully prepared and applied calendar comes from Caldwell and Igun's study of three approaches to age estimation in Nigeria. In their survey, the interviewers first recorded the age stated by the respondent. They then used a carefully constructed historical calendar to estimate the age. Finally, they tried to solicit a list of at least six persons living in the area who were the same age as each individual interviewed. They used this list of six contemporaries to determine two estimates of the person's age. The first assigned the individual the modal age reported by his six contemporaries. The second approach tried to determine which of the seven individuals (the respondent plus the six contemporaries) was most likely to have reported correctly and used that person's age as the correct one. The results were then analyzed by comparing the first reported age to the age estimated using the calendar and to the two estimates based on cohort reports, the modal age and the most reliable or "best" cohort age.

Table A-1 presents the errors in responses to the

TABLE A-1 Percentage of Agreement Between Ages Reported in Response to a Simple Question on Age and Ages Estimated by Alternative Approaches: Nigeria

	Males			Females		
Reported Age	Historical Calendar	Modal Age of Cohorts	"Best" Cohort Estimate	Historical Calendar	Modal Age of Cohorts	"Best" Cohort Estimate
0-4	98	93	93	98	93	94
5-9	93	90	91	94	90	91
10-14	87	84	86	88	85	81
15-19	87	84	83	88	85	81
20-24	83	84	83	84	81	80
25-29	77	79	80	78	82	78
30-34	71	74	75	75	78	79
35-39	73	77	75	67	73	69
40-44	66	76	77	75	79	72
45-49	68	75	67	68	68	68
50-54	66	78	81	65	78	72
55-59	55	67	62	64	71	71
60-64	64	75	67	64	78	67
65-69	66	65	65	74	74	84
70-74	73	84	82	67	80	79
75+	61	63	69	71	82	82
Total	81	82	82	83	83	81

Source: Caldwell and Igun, 1971:296-297.

simple question on age that are implied by a comparison with each of the three more complex age-estimation methods. The three estimates of the overall proportion reporting their age correctly were virtually the same: about 82 percent for each sex. However, by examining the proportions estimated to be "correct" in each age group we find important differences among the three methods. For females, the historical calendar approach seems to underestimate the number of errors for women under age 25 and to exaggerate the number of errors over age 50 relative to the cohort approaches. For males, the historical calendar approach appears to overstate the errors at ages 30-54 and at 70 and over and to slightly underestimate the errors at other ages.

Table A-2 summarizes the pattern of misreporting implied by each of the three age-estimation methods. It is clear from this table that the historical approach leads to very different conclusions regarding the pattern of misreporting than do the cohort approaches. The calendar approach suggests that all persons over the age of 10 tend to understate their age. Caldwell and Igun conclude that this provides "corroboration for the suspicion that the historical calendar method might tend to overstate" the ages of respondents (1971:295).

Other evidence that the use of historical calendars might bias reported ages upward comes from data presented by Scott and Sabagh. In the second round of the Multi-Purpose Survey of Morocco, males aged 15-20 were asked how many times they had observed Ramadan. Since Ramadan is generally first celebrated at the time a male reaches puberty, comparing the number of times a man has celebrated Ramadan with other estimates of his age should provide evidence on the accuracy of the estimates. What is significant for our purposes is that by using the ages estimated by reference to the events calendar, the mean age at first Ramadan comes to about 15.7 years, whereas using age estimates based on appearance and responses, the mean age was 14.2 years in the first round and 14.7 in the second round (1970:102). It therefore appears that for males aged 15-20, use of historical calendars tended to increase the reported age.

In Gibril's analysis of the tape recordings from Gambia, he tried to evaluate the interviewer's effect on the reported age. By comparing the age reported by the respondent with the age actually recorded by the enumerator he concluded that the interviewers in Gambia, using historical calendars, tended to overstate ages (1979:69).

TABLE A-2 Net Percentage of Respondents Overstating Their Age, Based on Three Age-Estimation Techniques: Nigeria

Reported Age	Males			Females		
	Historical Calendar	Modal Age of Cohorts	"Best" Cohort Estimate	Historical Calendar	Modal Age of Cohorts	"Best" Cohort Estimate
0-4	2	3[a]	6[a]	2	3	4
5-9	1	2	-1	0	0	1
10-14	-3	0	0	-2	-1	1
15-19	-3	0	3	0	5	3
20-24	-5	0	1	-2	-1	0
25-29	-7	1	2	-6	8	-4
30-34	-11	0	-5	-9	2	21
35-39	-9	-3	1	-7	-1	5
40-44	-16	0	1	-7	7	6
45-49	-8	11	3	-10	8	2
50-54	-14	-8	-7	-9	-2	-8
55-59	-21	-1	0	-16	-3	-13
60-64	-4	-5	-3	-3	-6	5
65-69	-20	5	-9	-14	6	-4
70-74	-17	-4	-6	-9	4	5
75+	-17	-11	-11	-1	8	8
Total	-5	0	0	-3	1	3

Note: The percentages shown represent the percentage reported in a higher five-year age group minus the percentage reported in a lower five-year age group.

[a] These two figures have been adjusted from the original data, which indicated that a percentage of those aged 0-4 had been reported in a lower five-year age group--which cannot be correct.

Source: Based on Caldwell and Igun, 1971:296-297.

In three of the cases mentioned above, there appears to be a tendency for age to be overstated when it is estimated from historical calendars. However, Scott and Sabagh report some preliminary findings from a report by W. A. Belson on a study of memory of public events which suggest that understatement might be the effect in some populations: "Except in the case of recent events, the general tendency was toward post-dating. Errors were often very substantial and were larger among respondents in the less skilled occupational groups" (1970:106). A bias of this sort would lead to an understatement of age if the age at the time of the event were reported accurately.

There is one case in which a clear bias toward understatement of age has been linked to the use of historical calendars. In a study of a village in rural Haiti, Chen and Murray (1976) were able to use a combination of baptismal records and sibling and peer matching to derive reliable age estimates for 90 percent of the population. Baptismal records were located for about 68 percent of the population, about 15 percent were siblings of people with baptismal records, and the remainder were matched with childhood friends who were slightly older or younger. Murray compared these ages with the ages determined for adults using a calendar of the presidents of Haiti, since it is widely believed that everyone in Haiti knows who was president at the time of his birth. He found first of all that 31 percent of the adult respondents claimed they did not know who was president at the time of their birth. Most of those who said they did not know were over age 50. Of the remaining 285 adult respondents, 48 percent named the wrong president. Murray concludes that this belies the "stereotype that aging by Presidents is the ancient, traditional aging technique of the Haitian peasant" (1979). In examining the errors that were made, he discovered that in more than 90 percent of these cases the person named the president subsequent to the correct one. This means that in more than 40 percent of the cases in which an adult claimed to know who was president at the time of his or her birth the resulting age would have been lower than the correct age.

In every one of these cases, the evidence suggests that Caldwell and Igun were correct when they concluded: "The possibility should not be ignored that the historical method actually introduces non-random errors" (1971:301-302).

Glossary

AGE HEAPING A tendency for enumerators or respondents to report certain ages instead of others; also called age preference or digit preference. Preference for ages ending in 0 or 5 is widespread.

AGE PATTERN OF FERTILITY The relative distribution of a set of age-specific fertility rates. It expresses the relative contribution of each age group to total fertility.

AGE RATIO The ratio of the population in a given age group to the average of the populations in the two neighboring age groups, times 100.

AGE-SPECIFIC FERTILITY RATE The number of births occurring during a specified period to women of a specified age or age group, divided by the number of person-years-lived during that period by women of that age or age group. When an age-specific fertility rate is calculated for a calendar year, the number of births to women of the specified age is usually divided by the midyear population of women of that age.

AGE-SPECIFIC MORTALITY RATE The number of deaths occurring during a specified period to persons (usually specified by sex) of a specified age or age group, divided by the number of person-years-lived during that period by the persons of that age or age group. When an age-specific mortality rate is calculated for a calendar year, the number of deaths to persons of the specified age is usually divided by the midyear population of persons of that age. Age-specific mortality rates are generally denoted by ${}_nM_x$, the annual death rate to persons aged x to x + n.

AGE STANDARDIZATION A procedure of adjustment of crude rates (birth, death, or other rates) designed to reduce the effect of differences in age structure when comparing rates for different populations.

BIRTH HISTORY A report of the number and dates of all live births experienced by a particular woman; see also pregnancy history. The sex of each child, the survival of each child to the date of the interview, and, where pertinent, the date of death are also generally recorded.

BIRTH ORDER The ordinal number of a given live birth in relation to all previous live births of the same woman (e.g., 5 is the birth order of the fifth live birth occurring to the same woman).

BIRTH RATE See crude birth rate.

CHANDRASEKARAN-DEMING TECHNIQUE A procedure to estimate the coverage of two independent systems collecting information about demographic or other events, based on the assumption that the probability of an event being recorded by one system is the same whether or not the event is recorded by the other system. The events from both systems are matched to establish M, the number of events recorded by both systems; U_1, the number recorded only by system 1; and U_2, the number recorded only by system 2. The Chandrasekaran-Deming formula then estimates total events, N, as

$$\hat{N} = M + U_1 + U_2 + \frac{U_1 U_2}{M}.$$

CHILDBEARING AGES The span within which women are capable of bearing children, generally taken to be from age 15 to age 49 or, sometimes, to age 44.

CHILDREN EVER BORN(E) The number of children ever borne alive by a particular woman; synonymous with parity. In demographic usage, stillbirths are specifically excluded.

COHORT A group of individuals who experienced the same class of events in the same period. Thus an age cohort is a group of people born during a particular period, and a marriage cohort is a group of people who married during a particular period. The effects of a given set of mortality or fertility rates are often illustrated by applying them to hypothetical cohorts.

COHORT FERTILITY The fertility experienced over time by a group of women or men who form a birth or a marriage cohort. The analysis of cohort fertility is contrasted with that of period fertility.

CRUDE BIRTH RATE The number of births in a population during a specified period divided by the number of person-years-lived by the population during the same period. It is frequently expressed as births per 1,000 population. The crude birth rate for a single year is usually calculated as the number of births during the year divided by the midyear population.

CRUDE DEATH RATE The number of deaths in a population during a specified period divided by the number of person-years-lived by the population during the same period. It is frequently expressed as deaths per 1,000 population. The crude death rate for a single year is usually calculated as the number of deaths during the year divided by the midyear population.

CUMULATED FERTILITY An estimate of the average number of children ever borne by women of some age x, obtained by cumulating age-specific fertility rates up to age x; also often calculated for age groups.

DEATH RATE See crude death rate.

DE FACTO POPULATION A population enumerated on the basis of those present at a particular time, including temporary visitors and excluding residents temporarily absent. See de jure population.

DE JURE POPULATION A population enumerated on the basis of normal residence, excluding temporary visitors and including residents temporarily absent. See de facto population.

DIGITAL PREFERENCE See age heaping.

EXPECTATION OF LIFE AT BIRTH The average number of years that a member of a cohort of births would be expected to live if the cohort were subject to the mortality conditions expressed by a particular set of age-specific mortality rates. Denoted by the symbol e(o) in life table notation.

FERTILITY HISTORY Either a birth history or a pregnancy history.

FORWARD SURVIVAL A procedure for estimating the age distribution at some later date by projecting forward an observed age distribution. The procedure uses survival ratios, often obtained from model life tables. The procedure is basically a form of population projection without the introduction of new entrants (births) to the population.

GENERAL FERTILITY RATE The ratio of the number of live births in a period to the number of person-years-lived by women of childbearing ages during the period. The general fertility rate for a year is usually calculated as the number of births divided by the number of women of childbearing ages at midyear.

GROSS REPRODUCTION RATE The average number of female children a woman would have if she survived to the end of her childbearing years and if, throughout, she were subject to a given set of age-specific fertility rates and a given sex ratio at birth. This number provides a measure of replacement fertility in the absence of mortality.

GROWTH RATE The increase or decrease of a population in a period divided by the number of person-years-lived by the number of person-years-lived by the population during the same period. The increase in a population is the result of a surplus (or deficit) of births over deaths and a surplus (or deficit) of immigrants over emigrants. (The annual increase is often expressed as a fraction of the total population at the beginning of the year, but this convention has the inconvenient characteristic of not being readily defined for a five-year interval and of being unequal to the difference between the birth rate and the death rate even in the absence of migration.) See also rate of natural increase.

INFANT MORTALITY RATE The number of deaths of children under 1 year of age occurring in the same year; also used in a more rigorous sense to mean the number of deaths that would occur under 1 year of age in a life table with a radix of 1,000, in which sense it is denoted by the symbol ${}_1q_0$.

LIFE TABLE A listing of the number of survivors at different ages (up to the highest age attained) in a hypothetical cohort subject from birth to a particular set of age-specific mortality rates. The rates are usually those observed in a given population during a particular period of time. The survivors of the radix to age x are generally denoted by l(x). The tabulations commonly accompanying a life table include other features of the cohort's experience: its expectation of life at each age x, denoted by e(x); the probability of surviving from each age x to age x + n, denoted by ${}_nq_x$; the person-years-lived by the hypothetical cohort as it ages from age x to age x + n, denoted by ${}_nL_x$ (also equivalent to the population aged x, x + n in a stationary population experiencing a number of births each year equal to the *radix* of the life table); and the person-years-lived by the hypothetical cohort from age x onward, denoted by T(x).

LOGIT The logit of a proportion p is 1/2 ln[p/(1 - p)]. As a linearizing transformation, the logit has been proposed as the basis of a model life table system in which the logit of a probability of dying by age x ($_xq_0$) is related linearly to the logit of a standard probability of dying by age x ($_xq_0^s$) so that

$$\text{logit}\ ({}_xq_0) = \alpha + \beta\ [\text{logit}\ ({}_xq_0^s)],$$

where α is a measure of mortality level relative to the standard and β is a parameter that alters the shape of the standard mortality function.

MARITAL FERTILITY Any measure of fertility in which the births (in the numerator) are births to married women and in which the number of person-years-lived (in the denominator) also pertains to married women. In some instances, the designation "married" includes persons in consensual unions.

MEDIAN The value associated with the central member of a set that is ordered by size or some other characteristic expressed in numbers.

MEAN AGE OF CHILDBEARING The average age at which a mortality-free *cohort* of women bear their children according to a set of *age-specific fertility rates*.

MEAN AGE OF CHILDBEARING IN THE POPULATION The average age of the mothers of the children born in a population during a year. This measure incorporates the effects of both mortality and the age distribution.

MODEL LIFE TABLE An expression of typical mortality experience derived from a group of observed *life tables*.

MOVING AVERAGES The successive averaging of two or more adjacent values of a series in order to remove sharp fluctuations.

MYERS INDEX An index of digit preference that essentially sums in turn the population ending in each digit over some age range, often 10-89, expressing the total as a percentage of the total population, and which avoids the bias introduced by the fact that the population is not evenly distributed among all ages by repeating the calculations 10 times, once for each starting digit, and averaging the results. The difference between the average percentage for each digit and the expected value of 10 percent provides a measure of the preference for or avoidance of the digit over the age range considered.

NATURAL FERTILITY The age pattern of marital fertility observed in non-contraceptive populations where reproductive behavior is not affected by the number of children already born.

NET MIGRATION The difference between gross immigration and gross emigration.

NET REPRODUCTION RATE The average number of female children born per woman in a cohort subject to a given set of age-specific fertility rates, a given set of age-specific mortality rates, and a given sex ratio at birth. This rate measures replacement fertility under given conditions of fertility and mortality: it is the ratio of daughters to mothers assuming continuation of the specified conditions of fertility and mortality.

OWN-CHILDREN METHOD A refinement of the reverse-survival procedure for fertility estimation, whereby estimates of age-specific fertility rates for the recent past are obtained by relating mothers to their own children, using information on relationship and other characteristics available from a census or survey.

PARITY See children ever born.

PARTIAL BIRTH RATE The proportion of the population that enters (that is, is "born" into) a given age category in a year. The age categories used are normally open-ended, thus the partial birth rate x+ designates the proportion of the population becoming x years and older.

PARTIAL DEATH RATE The proportion of the population that leaves (that is, "dies" out of) a given age category in a year. See partial birth rate.

PERIOD FERTILITY The fertility experienced during a particular period of time by women from all relevant birth or marriage cohorts; see also cohort fertility.

P/F RATIO METHOD A consistency check for survey information on fertility. Information on recent fertility is cumulated to obtain measures that are equivalent to average parities. Lifetime fertility in the form of reported average parities by age group (P) can then be compared for consistency with the parity-equivalents (F) by calculating the ratio P/F for successive age groups. If certain assumptions about error patterns are met, an improved estimate of fertility can sometimes be obtained by correcting the age pattern of current fertility to agree with the level of lifetime fertility reported by younger women.

PREGNANCY HISTORY A report of the number and the dates of occurrence of all the pregnancies experienced by a particular woman. The outcome of the pregnancy--live birth, stillbirth, fetal death--is also recorded.

RADIX The hypothetical birth cohort of a life table. Common values are 1, 1,000, and 100,000.

RATE OF NATURAL INCREASE The difference between the births and deaths occurring during a given period divided by the number of person-years-lived by the population during the same period. This rate, which specifically excludes changes resulting from migration, is the difference between the crude birth rate and the crude death rate.

RETROSPECTIVE SURVEY A survey that obtains information about demographic events that occurred in a given past period, generally terminating at the time of the survey.

REVERSE PROJECTION See reverse survival.

REVERSE SURVIVAL A technique to estimate an earlier population from an observed population, allowing for those members of the population who would have died according to observed or assumed mortality conditions. It is used as a method of estimating fertility by calculating from the observed number of survivors of a given age x the expected number of births that occurred x years earlier. (In situations for which both fertility and mortality are known or can be reliably estimated, reverse survival can be used to estimate migration.)

ROBUSTNESS A characteristic of estimates that are not greatly affected by deviations from the assumptions on which the estimation procedure is based.

SEX RATIO AT BIRTH The number of male births for each female birth, or male births per 100 female births.

SINGULATE MEAN AGE AT MARRIAGE (SMAM) A measure of the mean age at first marriage, derived from a set of proportions of people single at different ages or in different age groups, usually calculated separately for males and females.

STABLE POPULATION A population exposed for a long time to constant fertility and mortality rates, and closed to migration, establishes a fixed age distribution and constant growth rate characteristic of the vital rates. Such a population, with a constant age structure and constant rate of growth, is called a stable population.

STATIONARY POPULATION A stable population that has a zero growth rate, with constant numbers of births and deaths per year. Its age structure is determined by the mortality rates and is equivalent to the person-years-lived (${}_nL_x$) column of a conventional *life table*.

SURVIVAL RATIO The probability of surviving between one age and another; often computed for age groups, in which case the ratios correspond to those of the person-years-lived function, ${}_nL_x$, of a *life table*. Also called *survivorship probabilities*.

SURVIVORSHIP PROBABILITIES See *survival ratio*.

SYNTHETIC PARITY The average parity calculated for a hypothetical cohort exposed indefinitely to a set of period *age-specific* *fertility rates*.

TOTAL FERTILITY RATE (TFR) The average number of children that would be born per woman if all women lived to the end of their childbearing years and bore children according to a given set of *age-specific fertility rates*; also referred to as total fertility. It is frequently used to compute the consequence of childbearing at the rates currently observed.

UNITED NATIONS AGE-SEX ACCURACY INDEX An index of age reporting accuracy that is based on deviations from the expected regularity of population size and sex ratio, age group by age group. The index is calculated as the sum of (1) the mean absolute deviation from 100 of the age ratios for males, (2) the mean absolute deviation from 100 of the age ratios for females, and (3) three times the mean of the absolute difference in reported sex ratios from one age group to the next. The United Nations defines age-sex data as "accurate," "inaccurate," or "highly inaccurate" depending on whether the index is less than 20, 20 to 40, or greater than 40.

WHIPPLE'S INDEX A measure of the quality of age reporting based on the extent of preference for a particular target digit or digits. The index essentially compares the reported population at ages ending in the target digit or digits with the population expected on the assumption that population is a linear function of age. For a particular age range, often 23 to 62, the population with ages ending in the target digits is divided by one-tenth of the total population, the result then being multiplied by 100 and divided by the number of different target digits. A value of 100 indicates no preference for those digits, whereas values over 100 indicate positive preference for them.

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Contents

LIST OF TABLES ix

LIST OF FIGURES xii

PREFACE xiii

SUMMARY 1

1 INTRODUCTION 5

Bangladesh and Its People 6
Demographic Data Sources 8
Population Characteristics as Recorded by Censuses 11
Summary 31

2 FERTILITY 32

The Population Growth Estimation (PGE) Experiment 32
The National Impact Survey (NIS) 36
The Bangladesh Retrospective Survey of Fertility and Mortality (BRSFM) 38

The Bangladesh Fertility Survey (BFS) 43
The Cholera Research Laboratory (CRL) 49
Summary 50

3 MARITAL STATUS 53

4 MORTALITY 57

The Population Growth Estimation (PGE) Experiment 58
The Bangladesh Retrospective Survey of Fertility and Mortality (BRSFM) 71
The Bangladesh Fertility Survey (BFS) 88
The Cholera Research Laboratory (CRL) 91
Summary 92

5 REGIONAL VARIATION IN FERTILITY AND MORTALITY 95

6 POPULATION GROWTH IN BANGLADESH 98

GLOSSARY 105

REFERENCES 113

List of Tables

1. Data Sources by Type of Evidence 12
2. Enumerated Population by Sex and Religion in 1951, 1961, and 1974, and Intercensal Growth Rates 14
3. Distribution of the Population by Age and Sex, from Major Sources, 1951-75 17
4. Stable Population Estimates of the Male and Female Birth Rates of the Muslim Population in 1951, 1961, and 1974 20
5. Population Birth Rates and Sex Ratios at Birth of the Muslim Population, Implied by Stable Population Analysis of the Age Distributions in 1951, 1961, and 1974 22
6. Own-Children Estimates of Total Fertility Rates, 1964-73, Under Alternative Adjustments 25
7. Intercensal Cohort Survivorship Probabilities by Sex and Religion, 1951-61 and 1961-74 27
8. Model Life Table Mortality Levels Implied by Intercensal Cohort Survivorship Probabilities for 1951-61 and 1961-74 28
9. Fertility Estimates from the PGE, 1963-65 33
10. Comparison of Current Fertility from the PGE (1963-65) with Retrospective Fertility from the DSEP (1961-62) 35
11. Fertility Measures for Currently Married Women, from NIS (1968-69) and BFS (1975-76) 37